

*Textbook of  
Operative Dentistry*

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# *Textbook of Operative Dentistry (with MCQs)*

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### **Textbook of Operative Dentistry**

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*To  
Students and teachers as a  
mark of our gratitude for their  
valuable suggestions  
inspiration and appreciation*



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# *Foreword*

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I am very happy to write the foreword for the 'Textbook of Operative Dentistry with MCQs'. In the last three decades the theory and practice of Operative Dentistry have undergone a revolutionary change due to the developments in adhesive dentistry.

In this book a modified, comprehensive and complete classification of cavities has been given. This classification includes classes, divisions, subdivisions and types. A new class VII has been introduced. This classification gives complete location, size and distance of the pulpal wall from the pulp, which is very useful. The textbook has well labeled excellent diagrams making the subject very simple and self-explanatory.

This book has comprehensively covered all the topics of the subject with basic fundamentals and recent advances. Many new chapters have been included in this book which are the direct answers of the questions usually asked in BDS and MDS university examinations. The language is very simple and clear. The well illustrated and labelled presentations of the topics in this book with basic fundamentals and recent advances have made the reading very informative and interesting for the undergraduates, postgraduates, teachers and practitioners. For self-evaluation, 550 multiple choice questions have been given in the end. The MCQs cover all the chapters and are very useful especially to the students preparing for various competitive examinations. This is a very special feature of the book. Overall this is an excellent book.

**Dr. Anil Kohli**



# **Foreword**

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I am very much delighted to write the foreword for the 'Textbook of Operative Dentistry with MCQs' by Prof. Satish Chandra. The book contains almost all the latest information on the subject. Recently due to developments in the tooth colored materials and adhesive dentistry, the theory and practice of Operative Dentistry have made revolutionary improvements.

This book contains an improved, comprehensive and exhaustive classification of cavities, which includes seven classes with their divisions, subdivisions and types. This classification gives complete, almost three-dimensional picture of the cavity. The language is very simple. The diagrams are well labeled and self-explanatory. The subject matter is crystal, clear and very easy to understand.

The book has completely covered all the topics of the subject along with the basic fundamentals and recent advances. Most of the chapters contain the information, which are the direct answers to the questions usually asked in UG and PG examinations. The UG and PG students, researchers, teachers and practitioners will find the book very useful.

The MCQs completely covering the subject, shall be very useful to the students especially those preparing for various competitive examinations.

I strongly recommend this student-friendly book to all the BDS and MDS students.

**Prof. AP Tikku**





# **Preface**

The science and art of Operative Dentistry is ever changing. There has been unprecedented enhancement and advancement of dental materials and technologies of Operative Dentistry in last few decades. In keeping with these advances in adhesive dentistry and increased demands of esthetics, the practice and scope of Operative Dentistry is increasing by leaps and bounds.

Even though Operative Dentistry is the mother of all branches of dentistry, demand of esthetic and adhesive dentistry and the advances and developments within the last few decades have totally changed the scope and future of this branch. In clinical sciences the difference of opinion specially in the treatment modality leads to research. Controversies help the science to grow and flourish more and more through further research.

The original work of GV Black (1898) remains unchallenged as the baseline. In an effort to make the classification of cavities comprehensive, complete and more useful further modifications in the classification of cavities have been made including divisions and subdivisions and types in each class of cavity. A new class of cavity, class VII has been added. These modifications are more appropriate with adhesive restorative materials and new techniques. These modifications pinpoint the exact location of the cavity with its extensions and the depth towards the pulp, making the line of treatment and the prognosis almost definite and crystal clear by the classification itself.

An effort has been made to include the maximum possible relevant latest topics and new concepts of the subject. Nevertheless, the rapidity with which the developments are taking place makes completeness an impossibility. The syllabi of all the universities as well as recommendations of dental councils of almost all the countries are fully and completely covered.

This book is intended to teach the principles, practice and recent advances in the field of Operative Dentistry to undergraduates, postgraduates, researchers and practitioners. Simple and lucid language has been used as much as possible. Extensively labelled illustrations and photographs have been used to explain the text wherever required. To further make the book user-friendly, few chapters which directly answer the questions recently asked in the university examinations have been included. At the end 550 multiple choice questions and their answers have been given which will be very helpful to the students for recapitulation and for preparation for various examinations and competitions.

We shall be indebted to the readers for suggestions for further improving the book in the next edition. Such suggestions may kindly be sent to first author at the address, 250/4-6, Rajendra Nagar, Lucknow- 226004 (U.P.) India.

**Satish Chandra  
Shaleen Chandra  
Girish Chandra**

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# *Contents*

|                                                                                               |     |
|-----------------------------------------------------------------------------------------------|-----|
| 1 . Introduction, Aims and Scope of Operative Dentistry .....                                 | 1   |
| 2 . Clinical Aspects of Dental Anatomy, Histology and Physiology in Operative Dentistry ..... | 8   |
| 3 . Occlusion and Operative Dentistry .....                                                   | 20  |
| 4 . Clinical Aspects of Dental Caries .....                                                   | 29  |
| 5 . Patient Evaluation, Diagnosis and Treatment Planning .....                                | 45  |
| 6 . Primary Considerations for Operative Procedures .....                                     | 59  |
| 7 . Color and Shade Matching .....                                                            | 63  |
| 8 . Nomenclature, Classification and Fundamentals in Cavity (Tooth) Preparation<br>70         |     |
| 9 . Dental Materials .....                                                                    | 100 |
| 10 . Selection of Restorative Materials .....                                                 | 107 |
| 11 . Isolation of the Operating Field .....                                                   | 112 |
| 12 . Instruments and Equipment for Tooth Preparation .....                                    | 121 |
| 13 . Matrices, Retainers and Wedges (Separators) .....                                        | 139 |
| 14 . Infection Control .....                                                                  | 151 |
| 15 . Pain Control .....                                                                       | 156 |
| 16 . Pulp Protection .....                                                                    | 159 |
| 17 . Periodontal Aspects of Operative Dentistry .....                                         | 165 |
| 18 . Amalgam Restorations .....                                                               | 171 |
| 19 . Pin Retained Restorations .....                                                          | 199 |
| 20 . Microleakage .....                                                                       | 206 |
| 21 . Finishing and Polishing of Restorations .....                                            | 211 |
| 22 . Interim Restorations .....                                                               | 216 |
| 23 . Bonding .....                                                                            | 220 |
| 24 . Introduction to Composite and Other Direct Tooth-Colored Restorations<br>232             |     |
| 25 . Direct Tooth-Colored Restorations for .....                                              | 245 |
| Classes III, IV, V and VII Cavity Preparations                                                |     |
| 26 . Direct Composite Restorations for Classes I, II and VI Cavity Preparations .....         | 259 |
| 27 . Glass Ionomer Cement .....                                                               | 265 |

**xvi**    *Textbook of Operative Dentistry*

|                                                                                                                                           |            |
|-------------------------------------------------------------------------------------------------------------------------------------------|------------|
| 28. Indirect      Tooth-Colored      Restorations .....                                                                                   | 273        |
| 29. Cast      Metal      Restorations .....                                                                                               | 284        |
| 30. Restoration      of      Cervical      Lesions .....                                                                                  | 304        |
| 31. Conservative      Esthetic      Procedures .....                                                                                      | 311        |
| 32. Direct      Gold      Restorations .....                                                                                              | 327        |
| 33. Restorations      of      Badly      Decayed      and      Broken      Down      Teeth .....                                          | 336        |
| 34. Emergencies      and      Postoperative      Complications .....                                                                      | 345        |
| 35. Restoration      of      Endodontically      Treated      Teeth .....                                                                 | 349        |
| 36. Restoration      of      Noncarious      Defects .....                                                                                | 358        |
| 37. Restorations      and      Stomatognathic      System .....                                                                           | 365        |
| 38. Management      of      Discolored      Teeth .....                                                                                   | 370        |
| 39. Various      Designs      and      Shapes      of      Margins      of      Tooth      Preparations      and      Restorations<br>378 |            |
| <i>Multiple Choice Questions .....</i>                                                                                                    | <i>383</i> |
| <i>Index .....</i>                                                                                                                        | <i>421</i> |

# 1

## *Introduction, Aims and Scope of Operative Dentistry*

### **DEFINITION**

According to Mosby's dental dictionary, Operative dentistry deals with the functional and esthetic restoration of the hard tissues of individual teeth. More appropriately Operative dentistry is defined as that branch or speciality of the science and art of dentistry which deals with diagnosis, treatment, and prognosis of defects of hard tissues of the teeth (enamel, dentin and cementum) which do not require full coverage restorations for correction. Such corrections and restorations result in the restoration of proper tooth form, function and esthetics while maintaining the physiological integrity of the teeth in harmonious relationship with the adjacent hard and soft tissues. Such restorations enhance the dental and general health of the patient.

### **HISTORY**

Before 1840, dentists learned the trade by doing assistantship under more experienced dentists, but their knowledge was without any scientific basis, hence often disputes were there regarding various materials and treatment techniques. There was a dispute over the use of amalgam in 1840 which initiated formal dental education with the establishment of first dental college of the world at Baltimore in 1840.

Till 1900 AD, the term 'Operative dentistry' included all the dental services rendered to the patients, because all the dental treatments were considered to be an operation which was performed in the dental operating room or operatory. Later on due to development of techniques and knowledge, new dental specialities were recognized. Therefore, Operative dentistry is the mother of all the clinical subjects. At that time, relief of pain and extraction of teeth were the main objectives of Operative dentistry. Operative dentistry has been recognized as the foundation of dentistry because it has been the basic field for the development of other

specialities of dentistry. Operative dentistry is an integral and important part of dental practice. Operative dentistry is fundamental to the restorative and other clinical disciplines. Scientific progress in the field of dentistry was started by the introduction of amalgam. A mineral paste "Royal Mineral Succedaneum" was developed by two French dentists by mixing and triturating filings of Mexican silver coins with mercury. At that time this material was used in all carious teeth and also in precarious deep pits and fissures for prevention of caries.

Dr. G. V. Black (1898) is known as the "Father of Operative dentistry". He provided scientific basis to dentistry because his writings developed the foundation of the profession and made the field of operative dentistry organized and scientific. Dr. G. V. Black's writings, besides Operative dentistry also covered dental anatomy, caries, erosion and oral pathology, and were mostly related with the diseases of pulp and soft tissues and their appearance in clinical conditions. Principles of cavity preparation, teeth nomenclature, instrument formula and restorative materials were established by Dr. G.V. Black. Besides Black, other important early contributors to Operative dentistry were William Rogers, Charles Merry, S.C. Barnum, Jonathan Taft, W.H. Taggart, E.K. Wedelstaedt, Waldon I. Ferrier, Charles E. Woodbury and George Hollenback.

Till then dental caries was considered a gangrene-like disease. Louis Pasteur during the same period in France confirmed the role of microorganisms in diseases. Dr. Arthur, son of Dr. Black, continued his father's efforts to strengthen the scientific foundation of Operative dentistry. Later in the first half of twentieth century more emphasis was placed on the scientific foundation of dentistry. The practice of dentistry was regulated by the laws. Gradually frequency of untrained dentists was reduced. Continuous research resulted in further refinement of the techniques with better, long lasting and predictable results.

## 2 Textbook of Operative Dentistry

Advances and development since 1950 have drastically improved and increased the scope of Operative dentistry inspite of recently separating the speciality of Endodontics from it. Development of new tooth cutting devices and tooth colored adhesive and bonding restorative materials has revolutionized the scope of operative dentistry. However the work of Dr. G.V. Black is still the baseline although due to the advancement in techniques and materials, developments and modifications are continuously taking place, like ozone therapy for dental caries.

### CONSIDERATIONS AFFECTING OPERATIVE TREATMENT

#### Indications

Indications for operative procedures can be broadly divided into the following five headings.

1. Caries
2. Loss of the tooth structure due to attrition, abrasion, abfraction and erosion.
3. Malformed, discolored, or fractured teeth.
4. Esthetic improvement
5. Restoration replacement or repair.

#### Factors

The following are the important factors which require serious consideration before undertaking any operative procedure.

1. The condition of the affected tooth, other teeth and the oral and general health.
2. The diagnosis of the dental problem and the interaction of the affected area with other bodily tissues.
3. A treatment plan that can restore the tooth with all its functions.
4. Thorough knowledge of properties of the materials which can be used to restore the affected areas to proper shade, shape with functions, with a realization of limitations of materials and requirement of the patient.
5. The oral environment, like caries susceptibility of the patient.
6. Biological basis and function of the various tooth tissues and supporting tissues.
7. The knowledge of dental morphology, anatomy and histology.

8. The effect of the operative procedures on the treatment of other disciplines.
9. Infection control methods to safeguard dental personnel and the patients.

### A New Concept of Operative Approach

The new concept of an operative approach to preserve maximum healthy tooth tissues during operative procedures is a result of the following.

1. Use of fluoride releasing restorative materials.
2. A reduction in the incidence of caries because of increased preventive emphasis.
3. Use of multiple fluoride applications and proper sealant applications.
4. The advantage of the supragingival placement of restoration margins.

Research in materials and techniques has provided much improved operative services. There have been revolutionary improvements in materials and techniques in composite resins, ceramic and glass ionomer restorations because of the bonding of these materials to tooth structure. High copper amalgam restorations have vastly improved in early strength, corrosion resistance, marginal integrity and longevity.

More frequent operative procedures are now used for restorations and corrections in the following.

- a. All classes of cavities,
- b. Esthetic and/or functional correction of malformed, discolored or fractured teeth.
- c. Diastema closure can be effectively undertaken.

Recent approaches have resulted in conservation of tooth structure to the maximum extent. The advances in the operative procedures and techniques have resulted in preservation of maximum tooth structure and less trauma to the pulpal tissue and gingival tissue. The aim of the research activity is to develop the materials and techniques to completely bond restorative materials to the tooth structure. This has resulted in the reduction in extensive cavity preparations.

### AIMS OF OPERATIVE DENTISTRY

There are six fundamental aims of operative dentistry, which are as follows:

1. Diagnosis
2. Prevention

3. Interception
4. Preservation
5. Restoration
6. Maintenance

### **Diagnosis**

It is the determination of nature of disease, injury or congenital defect by examination, test and investigation. Proper diagnosis of lesions, including their locations and extent, is vital for planning the treatment including the design of the tooth preparation and the selection of restorative materials and procedures.

### **Prevention**

It includes the procedures undertaken for prevention before the appearance of any sign and symptom of disease. There are two main diseases usually managed in dental practice (1) caries and (2) periodontitis. Dental caries causes destruction of tooth structure, i.e. demineralization of inorganic structure and disintegration of organic structure, pulpal and periapical pathology. Dental caries is most significantly prevented by community water fluoridation. By community water fluoridation dental caries can be reduced by 55 to 60%. Use of sealing materials, for pits and fissures, can also reduce dental caries.

By regularly following meticulous oral hygiene instructions and dietary counseling, dental caries can be prevented to some extent.

Goswami and Bhuyan reported that tea is a rich source of fluoride and this fluoride has a strong binding ability to the enamel of tooth. The tea leaf also contains catechin and these catechins have significant antibacterial activity against *S. mutans*. The catechins can also inhibit the bacterial enzymes glucosyl transferase. Studies have shown that rinsing one's mouth with black tea significantly reduces plaque accumulation.

### **Interception**

It includes the procedures undertaken after some signs and symptoms of disease have appeared, in order to prevent the disease from developing into a more serious or full extent. Interception is a procedure, by which the teeth are restored to their normal health, form and function. In this, restoration is done in the lost

tooth structure. Tooth loss occurs due to dental caries, trauma, attrition, erosion, abrasion and malformation. Altering tooth form by restoration, selective recontouring, enhancing occlusal stability and changes in the patient's home care habits (i.e. proper tooth brushing and flossing) are also included in interception. By interceptive procedures, esthetics can be improved and it can prevent long-term psychological problems.

### **Preservation**

One of the important concepts of operative dentistry is preservation of what has remained along with an effort to restore what has been lost. Preservation of optimum health of teeth and soft tissue of oral cavity is obtained by preventive and interceptive procedures.

### **Restoration**

The ultimate goal of restorative treatment is re-establishment and maintenance of health, form, functions and esthetics. These restorative procedures have both scientific and artistic foundation. Successful placement of any restoration requires sound clinical judgement, both biological and mechanical, with an accompanying psychomotor skill capable of performing that which has been conceptualized.

### **Maintenance**

After restoration is done, it must be maintained for longer useful service.

## **SCOPE OF OPERATIVE DENTISTRY**

Operative dentistry is an integral part of dentistry. Dentistry involves vast and deep knowledge of the various specialities of science. All this knowledge is applied in operative dentistry for best achievement in dental and oral health and esthetics. Operative dentistry is continuously advancing, which directly affects dental practice through the development of new treatments and new biomaterials, and more sophisticated techniques to measure the health status of individuals.

### **Factors Affecting the Future Demand for Operative Dentistry**

Among the various factors affecting the future demand for operative dentistry, most important are the following:



## **4** Textbook of Operative Dentistry

### **Demographics**

All over the world, except a few countries, the population is increasing. Health consciousness, improved diet and better medical facilities have increased life expectancy of people. The child mortality rate has very much decreased. The average life of a person in last fifty years has increased from 30 to 45 years.

### **Affect of General and Dental Health of the Population**

*General health:* The general health of the people has improved. The ability to prevent or cure infectious diseases has led to an increase in life expectancy. The ability to control, partially or fully, some of the chronic diseases, is resulting in a larger proportion of elderly persons in the population.

*Dental and oral health:* The people of south east Asia in general are having bad dental and oral health. Though awareness towards good dental and oral health care has increased in the past few decades, the concept that teeth are for life time is being gradually accepted by the general public. Moreover, epidemiological studies indicate that the need for operative dentistry will increase in the future.

### **Economic Factors**

Operative dentistry is an expensive treatment. Economic status of people is gradually becoming higher. With this, the consumption of refined carbohydrates is also increasing resulting in more caries. Thus, the demand of operative dentistry in future is likely to increase.

## **DENTAL STATUS**

### **Caries**

Only in few advanced countries the incidence of caries has decreased due to fluoridation of community water supply and use of supplements of fluoride in other forms, but in most of the countries it is gradually increasing. This will also favorably affect the future demand of operative dentistry.

### **Teeth at Risk to Dental Diseases**

With the increase in the population as the number of adults and elderly persons is increasing, number of

serving natural teeth will also increase. Hence, the number of teeth at risk to dental diseases is gradually increasing and many of these are likely to require operative care. So, this will favorably affect the future demand of operative dentistry.

### **Periodontal Status**

Periodontal diseases are increasing with change in dietary habits and increase in life expectancy. In elderly persons and senior adults, gingival recession is a major factor in the development of root caries. Development of root caries is also likely to favorably affect the future demand of operative dentistry.

### **Missing Teeth**

The number of natural teeth present in oral cavity will increase. Even though partial edentulism will continue in the adult population, total edentulism (total absence of teeth) is decreasing dramatically in the elderly population. After losing few teeth people realise the importance of the remaining teeth and try to preserve them. Therefore, the persons in the age group of 30 to 40 years will be dental patients for the next 30 to 40 years. Partial edentulism will continue and therefore will be a source of demand for operative care of the remaining standing teeth in the future.

### **Projected Required Hours of Need for Operative Dentistry Services**

In general dental practice the projected required hours of need for operative dentistry services are gradually increasing. They are devoted mainly to the following operative procedures.

- a. Restorations of new lesions of enamel, dentin and cementum.
- b. Restorations to replace existing faulty restorations.
- c. Restorations in teeth with root caries.
- d. Restorations to enhance the esthetics of patients

*Root caries:* The elderly population is gradually increasing. These people will retain more natural teeth and experience more gingival recession which will result in more root caries. This will also affect the future demand of operative dentistry.

*Esthetic restorations:* A part of income of the dentist comes from esthetic restorations of malformed and malaligned teeth. Gradually people are becoming more

and more esthetic conscious and serious towards esthetic aspects. This factor will also increase the scope and future demand of operative dentistry.

*Replacement of restorations:* Old restorations may need replacement because of the following reasons.

1. Secondary caries
2. Marginal leakage
3. Fractured restorations
4. Availability of improved restorative materials
5. Changing esthetic concepts.

## **FUTURE OF OPERATIVE DENTISTRY**

The future of operative dentistry is very bright. The use of high and ultra high speed instrumentation along with the acknowledged benefits of water and spray coolants have also led to the concept of four-handed dentistry.

The bonding of restorations to tooth structure by etching has led to the development of many new composite materials and bonding techniques. The use of these composite materials has led to both increased esthetic qualities and resistance to wear.

It is hoped that in the future, more advanced treatment techniques and materials will be developed. There may not be any need of cavity preparation. Adhesive materials having hardness of enamel will be developed. Partial success has also been obtained in the regeneration of enamel. The past has undergone maximum changes and the future illustrates the dynamics of operative dentistry which is a constantly changing and advancing speciality.

For the development and professional growth of any branch of clinical science, continuous research is the primary requirement. By research in operative dentistry, more knowledge is being added to the understanding of the etiology, diagnosis, materials, techniques and treatment of dental diseases. Continuous research will help in better understanding about cariology and etiology of other dental diseases. By the continuous research and improvements, better restorative materials with improved techniques are being continuously marketed. Important improvements are the following.

### **Acid Etch Technique and Composite Resins**

In operative dentistry, acid etch technique is commonly used. More improved composite resins have been developed. In this way, more operative restorations

requiring much less cutting in anterior and posterior teeth are being done. The use of this technique and composite materials has reduced the potential toxicity of older restorative materials like silver amalgam. In silver amalgam, mercury and nickel (being used in traces by some manufacturers) are harmful.

### **Lasers**

Lasers are being used for prevention of caries, because they cause enamel to become more resistant to demineralization. Lasers are also being used in etching of enamel for composite restoration. They are also being used in cavity preparation. The use of lasers in dentistry may lead to a new mechanism for welding the dental alloys.

### **Castable Ceramic Materials**

Now, after long research and clinical trials, castable ceramic materials are being popularly used in day to day clinical practice. They have significant advantages over old conventional ceramics and other restorative materials.

### **Computer Generated Ceramic Restorations or CAD-CAM Ceramic Restorations**

A lot of interest has been shown for their day-to-day clinical use. Further improvements in technology are being tested for their wider use in all types of restorations.

### **Concepts of Cariology**

Other techniques are being tested for treating dental caries, other than restorative materials. If carious lesions are beginning on surfaces of teeth, they can be intercepted by remineralization, and need for restorations can be eliminated. Enamel can be made more resistant to demineralization to prevent dental caries.

### **Adhesively Bonded Composite Materials**

Attempts are being made to develop composite and other materials which will adhesively and absolutely bond to enamel and dentin. When developed, it will be a boon to operative dentistry. Restoration by this type of material will require only minimal or no preparation of teeth except the removal of only the carious portion which will eliminate the anxiety of patients, and uncooperative patients will become co-operative.

## 6 Textbook of Operative Dentistry

### **Radio-Visio-Graphy (RVG) (Digitization of Ionizing Radiation)**

It is a new radiographic system in which there is digitization of ionizing radiation. It provides instant image on the screen of a video monitor. It reduces radiation dose by about 80 percent. Its other main advantages are elimination of X-ray film and instant image display. It is very useful in the practice of operative dentistry as during cavity preparation the distance from the pulp can be constantly monitored and pulpal exposure can be easily avoided (Fig. 1.1).

#### **Research will make the Treatment a Pleasure**

Dental research and efforts will continue to seek newer materials and treatment methods, which will be more efficient and not at all stressful for all the patients, especially to children and elderly patients. This will make dental treatment a pleasure to all. In research work intraoral camera is very useful (Fig. 1.2).

*Bogra et al reported the following*

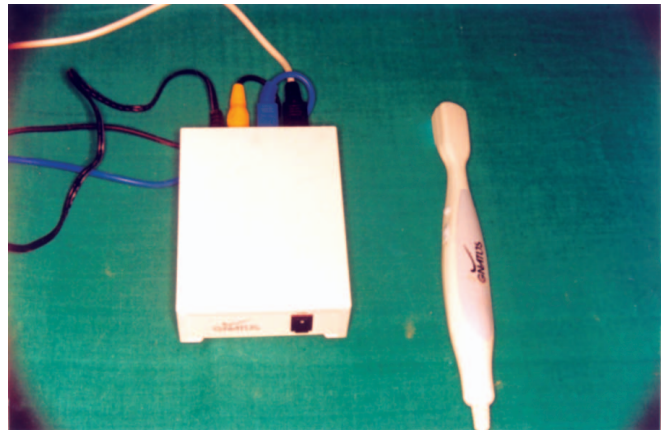
1. Offering an alternative to conventional treatment, a new approach based on ozone, a powerful biocide, to rapidly penetrate the bacteria and kill them in their protected niche has been introduced.
2. Ozone therapy involves a 10 seconds application of ozone gas to eliminate microorganism in caries lesions. Significantly reducing treatment time and cost, this therapy is less invasive than previous methods and conserves more of tooth's natural structure.
3. This painless ozone gas treatment for tooth decay has been proven to halt primary root caries, primary pit and fissure caries and even clinically reverse the lesions.
4. Ozone therapy is based on the premise that a normal bacteria type will re-grow over the clean surface, and minerals from the special mouth rinses and saliva will be absorbed into the tooth surface.
5. Ozone alters metabolic products of bacteria that inhibit remineralization. It also removes plaque pyruvate which may suppress the development of tooth demineralization.

#### **Dentinometer/Prepometer and Other Devices**

These are small battery operated instruments which measure the thickness of remaining pulpal wall i.e.



**Fig.1.1:** RVG in use



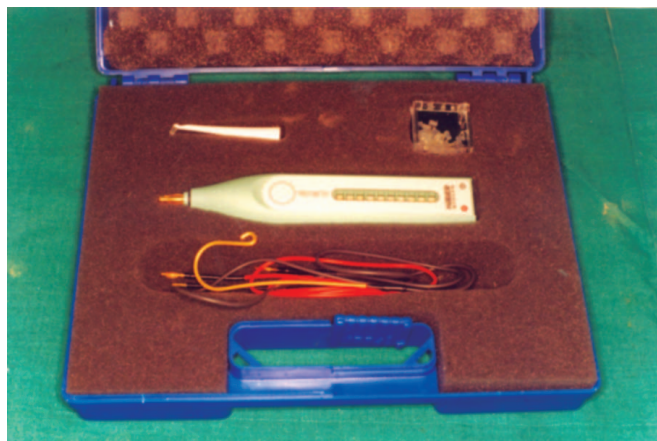
**Fig. 1.2:** Intraoral digital camera

distance between pulpal wall and the pulp. They are highly thermosensitive instruments and very correctly measure the thickness of dentin over vital pulp when it remains less than two mm. The heat of vital pulp is transmitted through the remaining dentin to the dentinometer/prepometer, which is measured in numericals, thereby showing the correct thickness of the remaining dentin. Some devices measure the thickness by viscosity of the dentinal fluid and some by other means (Fig. 1.3).

#### **Modification in the Black's Classification of Cavities**

The modification includes divisions, subdivisions and types in each class and a new class VII. This modification also includes the proximity of the pulp to the pulpal





**Fig. 1.3: Prepometer**

wall where the pulpal wall is thinnest from clinical point of view. This classification is the most important factor to guide the treatment to be followed and gives indications about the prognosis of the tooth. This has been described in detail in chapter 8.

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# 2

## *Clinical Aspects of Dental Anatomy, Histology and Physiology in Operative Dentistry*

Good knowledge of dental anatomy, histology, physiology and occlusion is the foundation stone of operative dentistry. Thorough knowledge of morphology, dental anatomy, histology, physiology and occlusion is essential for good practice of operative dentistry.

### DENTAL ANATOMY

#### Dentition

In human beings, two sets of dentition erupt during the life cycle from childhood to adulthood. Childhood dentition is known as deciduous or primary dentition in which 10 mandibular and 10 maxillary teeth erupt. There is no premolar in deciduous dentition. The second set of dentition is called the permanent dentition, in which 16 mandibular and 16 maxillary teeth erupt.

#### Types of Teeth

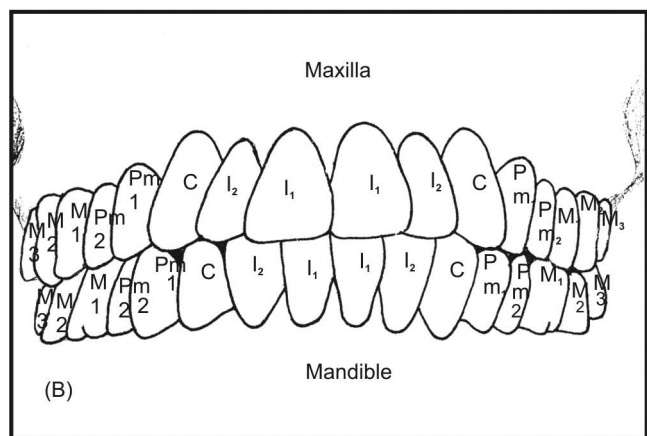
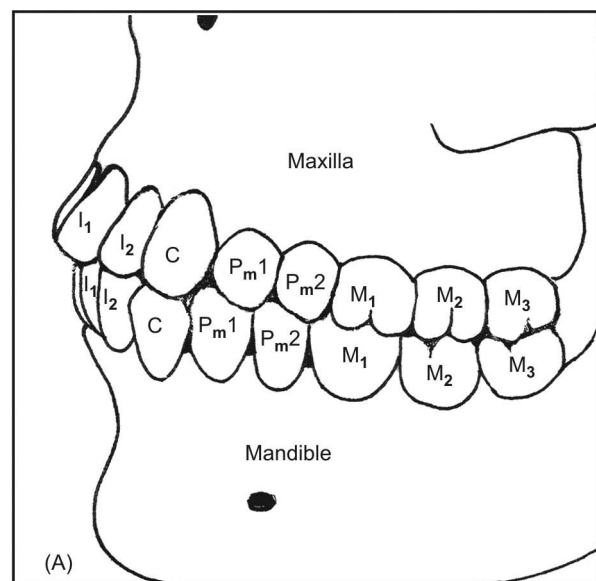
Based on form and function, human teeth are divided into different classes. The incisors, canines and molars are present in the deciduous as well as in the permanent dentition. The premolars are present only in the permanent dentition (Figs 2.1A and B).

#### Incisors

The incisors function for incising, cutting and shearing of food. These teeth are also important for esthetics and phonetics.

#### Canines

The canines are the teeth with longest roots. These are located at the turning points of the dental arch. Their function is seizing, piercing and tearing of food. They also help in cutting. Because of the bulky form of the



**Fig. 2.1:** Teeth of adult aged 60 years showing proximal attrition at contact areas (in centric occlusion) (A) Side view (B) Front view

crown and the longer root, these teeth are stronger and more stable. Therefore, the canines are good abutments for fixed or removable prosthesis, and anchorage for orthodontic appliances.

### Premolars

Like canines, the premolars help in tearing of the food. Like molars they also help in grinding of food. Their facial cusp is like that of canines. The lingual cusp of maxillary premolars and molars has a more rounded form. For occlusal contacts and function, a series of curves in the form of concavities and convexities are present on the occlusal surface.

### Molars

Molars are the large and multicusped teeth. These act as a fulcrum during function. The molars help in crushing, grinding and chewing of food to small fragments, which can be swallowed and digested easily. Premolars and molars function in the final mastication of the food. These teeth also maintain the vertical dimension of the face.

## TOOTH NUMBERING

A clear and convenient means of identification of specific tooth is necessary for programming procedures in operative dentistry because there are total 52 teeth in deciduous and permanent dentitions. But there is no universal agreement on one system for tooth designations, which is accepted and followed all over the world. Mainly three separate systems for tooth numbering are being followed and taught in various dental colleges.

### 1. Universal System of Tooth Numbering

The American Dental Association has described a tooth designation system known as the Universal system of tooth numbering. It is as follows.

#### a. Deciduous (Primary) Dentition

Consecutive uppercase letters (A through T moving clockwise) are assigned to identify the deciduous dentition. The deciduous dentition is divided into quadrants as follows.

|                      |   |   |   |   |            |  |   |   |   |   |   |                     |  |  |
|----------------------|---|---|---|---|------------|--|---|---|---|---|---|---------------------|--|--|
|                      |   |   |   |   | Maxillary  |  |   |   |   |   |   |                     |  |  |
| Patient's right side | A | B | C | D | E          |  | F | G | H | I | J | Patient's left side |  |  |
|                      | T | S | R | Q | P          |  | O | N | M | L | K |                     |  |  |
|                      |   |   |   |   | Mandibular |  |   |   |   |   |   |                     |  |  |

A denotes maxillary right second deciduous molar and J denotes maxillary left second deciduous molar. K denotes the mandibular left second deciduous molar and T denotes mandibular right second deciduous molar.

#### b. Permanent Dentition

Tooth numbering of permanent dentition presented by universal system is as follows.

|                         |    |            |    |    |    |    |    |    |  |    |    |    |    |    |    |    |    |                        |  |
|-------------------------|----|------------|----|----|----|----|----|----|--|----|----|----|----|----|----|----|----|------------------------|--|
|                         |    | Maxillary  |    |    |    |    |    |    |  |    |    |    |    |    |    |    |    |                        |  |
| Patient's<br>right side | 1  | 2          | 3  | 4  | 5  | 6  | 7  | 8  |  | 9  | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Patient's<br>left side |  |
|                         | 32 | 31         | 30 | 29 | 28 | 27 | 26 | 25 |  | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 |                        |  |
|                         |    | Mandibular |    |    |    |    |    |    |  |    |    |    |    |    |    |    |    |                        |  |

Number 1 denotes permanent maxillary right third molar and 16 denotes permanent maxillary left third molar. Moving clockwise permanent mandibular left third molar is denoted by 17 and permanent mandibular right third molar is represented by 32. Significance of this system is that each tooth has its unique letter or number.

### 1. Zsigmondy or Palmer System

It is the oldest and the most widely used system. In this system numbering of teeth starts from the mid-line, moves distally in both maxillary and mandibular arches.

#### a. Deciduous Dentition

In deciduous dentition quadrants and the teeth are designated as follows:

|                      |           |                 |           |  |                     |
|----------------------|-----------|-----------------|-----------|--|---------------------|
|                      |           | Maxillary arch  |           |  |                     |
| Patient's right side | E D C B A |                 | A B C D E |  | Patient's left side |
|                      | E D C B A |                 | A B C D E |  |                     |
|                      |           | Mandibular arch |           |  |                     |

#### b. Permanent Dentition

In permanent dentition quadrants and the teeth are designated as follows:

|                      |                 |                 |                 |                     |  |
|----------------------|-----------------|-----------------|-----------------|---------------------|--|
|                      |                 | Maxillary arch  |                 |                     |  |
| Patient's right side | 8 7 6 5 4 3 2 1 |                 | 1 2 3 4 5 6 7 8 | Patient's left side |  |
|                      | 8 7 6 5 4 3 2 1 |                 | 1 2 3 4 5 6 7 8 |                     |  |
|                      |                 | Mandibular arch |                 |                     |  |

## 10 Textbook of Operative Dentistry

### 2. Federation Dentaire Internationale (FDI) or Two-digit System

The Federation Dentaire Internationale adopted the two-digit system for designating teeth. This system has the following advantages

- Very easy to pronounce in conversation and dictation.
- Simple in teaching and understanding.
- Easy to translate into computer input.
- Easily communicable in print and by wire.
- Easy to make standard charts used in practice.

In the two-digit system, the first digit indicates the quadrant and the second digit, the specific tooth within that quadrant. In permanent dentition quadrants are denoted by the digits 1 to 4 and in deciduous quadrants are denoted by 5 to 8. In this system only, quadrants start in a clockwise sequence starting from the patient's upper right side. Federation Dentaire Internationale presents tooth numbering as follows:

|                      |                         |                         |                     |
|----------------------|-------------------------|-------------------------|---------------------|
| Permanent teeth      |                         |                         |                     |
| Maxillary            |                         |                         |                     |
| Patient's right side | 18 17 16 15 14 13 12 11 | 21 22 23 24 25 26 27 28 | Patient's left side |
| Mandibular           |                         |                         |                     |
| Patient's right side | 48 47 46 45 44 43 42 41 | 31 32 33 34 35 36 37 38 | Patient's left side |
| Deciduous teeth      |                         |                         |                     |
| Maxillary            |                         |                         |                     |
| Patient's right side | 55 54 53 52 51          | 61 62 63 64 65          | Patient's left side |
| Mandibular           |                         |                         |                     |
| Patient's right side | 85 84 83 82 81          | 71 72 73 74 75          | Patient's left side |

The digits are pronounced separately. For example, permanent canines are pronounced as one-three, two-three, three-three, and four-three (Fig. 2.2).

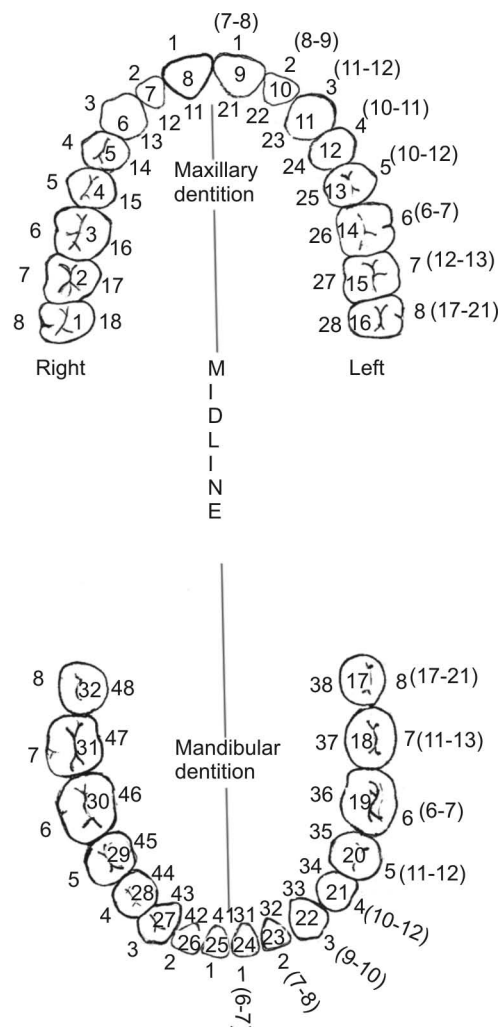
### NOMENCLATURE OF TOOTH SURFACES

The tooth surfaces are designated numerically as well as by letters depending upon their anatomical situations (Table 2.1).

**Table 2.1:** Designation of tooth surfaces

| Tooth surface                | Numerical | Letter | Situation                                                                   |
|------------------------------|-----------|--------|-----------------------------------------------------------------------------|
| Mesial                       | 1         | M      | Facing towards the midline                                                  |
| Distal                       | 2         | D      | Facing away from the midline                                                |
| Facial/<br>Labial/<br>Buccal | 3         | F/L/B  | Facing the lips and cheek, since both labial and buccal are facial surfaces |
| Lingual /<br>palatal         | 4         | L      | Facing the tongue or palate respectively                                    |

Contd...



**Fig. 2.2:** Numbering of permanent teeth: (1) Universal Numbering System (accepted by American Dental Association) – Numbers written on the occlusal surface of the teeth, (2) Palmer (Zsigmondy) System- Number written near facial surface of teeth in each quadrant starting from 1 to 8 (3) Federation Dentaire Internationale (FDI) or Two-Digit System - Numbers written near lingual surface of the teeth (4) Numbers written in brackets on facial side are years of eruption of the respective teeth

Contd...

|                      |   |     |                                                                           |
|----------------------|---|-----|---------------------------------------------------------------------------|
| Occlusal/<br>Incisal | 5 | O/I | Posterior tooth cutting surface [O]<br>Anterior tooth cutting surface [I] |
| Cervical             | 6 | C   | Near the neck of tooth on the crown                                       |
| Gingival             | 7 | G   | Near to the gingiva on the root                                           |



## DENTAL HISTOLOGY

The teeth consist of enamel, dentin, pulp and cementum (Fig. 2.3).

### ENAMEL

#### Structure and Clinical Considerations

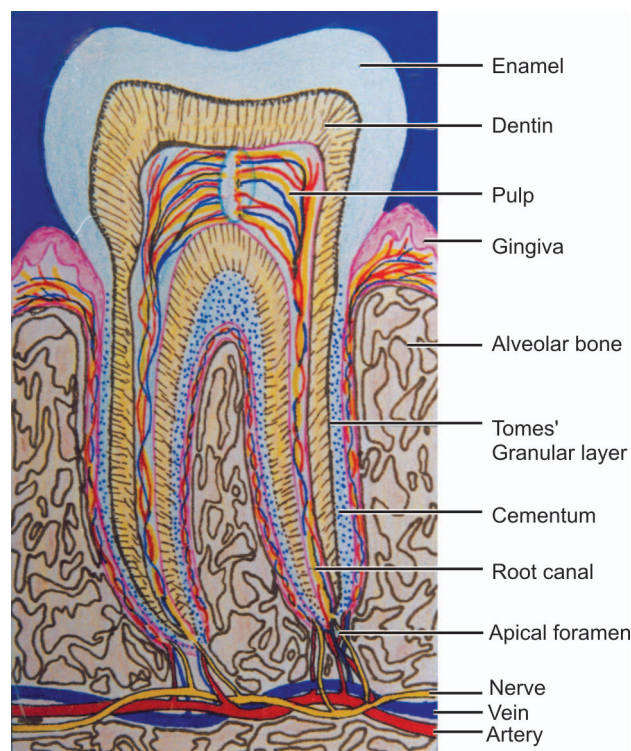
The anatomic crown of teeth is covered by acellular hard tissue known as enamel, which covers the anatomic crown of teeth. It is the hardest tissue of the body. The cells called ameloblasts form it.

#### Composition

It consists of 95 to 97 percent inorganic, 1 to 2 percent organic and about 1 to 3 percent water by weight. The thickness of enamel varies from one type of tooth to another type of tooth and from one area of tooth to another area. The average thickness of enamel at the incisal edges of incisors is 2 mm; at the cusp of premolar from 2.3 to 2.5 mm and at the cusp of molar it is 2.5 to 3.0 mm. Thickness of enamel decreases gradually from cusps or incisal edges to cemento-enamel junction.

Hardness of enamel varies over the external surface of a tooth according to the location of area. The hardness also decreases from outer surface of the enamel to its inner surface. The density of enamel also decreases from its outer surface to the dentino-enamel junction. Enamel has a rigid structure. It is brittle, has a high modulus of elasticity and low tensile strength. In comparison to enamel, dentin has high compressive strength, which acts as a cushion for enamel when masticatory forces are applied on it. When enamel rods do not have dentin base because of improper cavity design or caries, they are easily fractured from the neighboring rods. In cavity preparation, for maximal strength of underlying remaining tooth structure all enamel rods should be supported by healthy dentin base.

Enamel is composed of millions of enamel rods or prisms which are the largest structural components, as well as sheaths and a cementing inter-rod substance. Enamel rods or prisms run in a tortuous course from the dentino-enamel junction to the surface of the tooth. The diameter of rods increases from dentino-enamel junction towards the outer surface of enamel in a ratio of 1:2. In cross-section, they appear hexagonal and



**Fig. 2.3:** Mesio-distal section of mandibular molar with periodontium. Section of pulp has been shown at two levels. The right half is showing thicker vessels at the periphery and left half is showing thinner vessels at the central portion of the pulp

sometimes round or oval and many rods resemble fish scales.

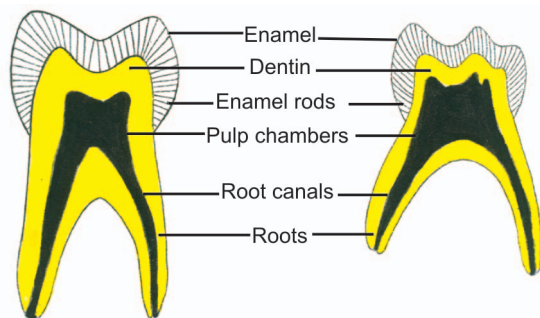
Enamel rods are arranged in such planes so as to resist the maximum masticatory forces. Rods are oriented at right angles to the dentino-enamel junction. Towards the incisal edge they become increasingly oblique and are almost vertical at the cusp tips. In the cervical region, there is difference in the direction of the enamel rods of deciduous and permanent teeth. The cervical enamel rods of deciduous teeth are inclined incisally or occlusally, while in permanent teeth they are inclined apically. Hence, direction of the enamel rods should be considered during tooth preparation so as to avoid unsupported enamel rods (Figs 2.4 and 2.5).

#### Grooves, Pits and Fissures

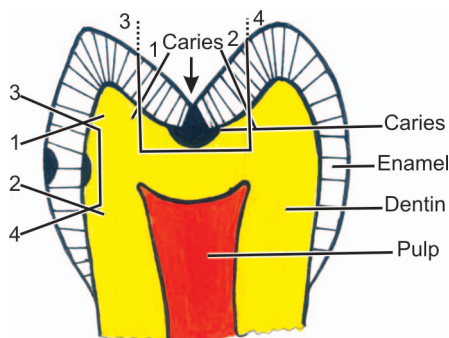
These occur mostly on occlusal surfaces of premolars and molars. These are formed at the junction of the



## 12 Textbook of Operative Dentistry



**Fig. 2.4:** Mesiodistal cross-section of (A) Permanent, (B) Deciduous maxillary second molars showing direction of enamel rods, pulp chambers and pulp canals



**Fig. 2.5:** Course of enamel rods in relation to cavity preparation in molar, 1 and 2 showing incorrect preparation of cavity margins. 3 and 4 showing correct preparation

developmental lobes of the enamel organs. Very deep pits and fissures are formed by faulty coalescence of developmental lobes of premolars and molars on occlusal surface. Thickness of enamel at the base of pit and fissure is less. In these pits and fissures food and bacteria accumulate and cause initiation of caries.

Grooves are developed by smooth coalescence of developmental lobes and form V-shaped grooves for escapement of food when cusps of teeth of opposite arch occlude during mastication.

### Dentino-enamel Junction

This is a hypermineralized zone and is about 30 microns thick. Dentino-enamel junction is scalloped in which crests are toward enamel and shallow depressions are in dentin.

### Tetracycline Discoloration

Discoloration due to tetracycline medication during childhood is very often observed. This discoloration is due to deposition of tetracycline in dentin. Sometimes a small amount may be deposited in enamel. Tooth-

colored surface binding restorative materials may be used to mask the discoloration.

## DENTIN

Dentin forms bulk of the crown and root of the teeth. It provides general form to the teeth. It is characterized as a hard tissue with tubules throughout its thickness. In dentinal tubules, processes of odontoblasts are present. Hence, dentin and bone are considered as vital tissues because both contain living protoplasm.

### Composition of Dentin

It contains approximately 65 percent inorganic material, 30 percent organic material, and 5 percent water and other materials. Inorganic component consists of hydroxyapatite crystals while organic components consist primarily of collagen.

### Physical Properties

Dentin is harder than bone and cementum but less harder than enamel (one-fifth hardness of enamel). Hardness of dentin near dentino-enamel junction is three times more than pulpal side of dentin. Its hardness also increases with increasing age due to mineralization. Modulus of elasticity of dentin is approximately  $1.67 \times 10^6$  PSI. The flexibility of dentin provides support to the nonresilient and more brittle enamel. The compressive strength of dentin is 266 MPa or 40000 PSI. Tensile strength of dentin is less than cortical bone and approximately one-half of that of enamel and its value is approximately 40 MPa (6000 PSI).

## STRUCTURE OF DENTIN

### Dentinal Tubules

The tubules follow a gentle 'S'-shaped curve in the tooth crown and are straighter in the incisal edges, cusps, and root areas. The ends of the tubules are perpendicular to dentino-enamel and dentino-cemental junctions. The dentinal tubules have lateral branches throughout the dentin, which are termed as canaliculi or microtubules. Each dentinal tubule is lined with a layer of peritubular dentin, which is much more mineralized than the surrounding intertubular dentin.

### Predentin

It is a layer of dentin, which is located adjacent to the pulp tissue, and its width is 2 to 6 micrometers. It is

first formed dentin and is not mineralized. When predentin is mineralized it becomes dentin and a new layer of predentin is formed circumpulpally.

## TYPES OF DENTIN

### Primary Dentin

#### Prenatal Primary Dentin

It is the dentin present at the time of birth, i.e. the dentin formed during intrauterine life.

#### Mantle Dentin

Mantle dentin is the first formed dentin in the crown underlying the dentino-enamel junction. It has fewer defects than circumpulpal dentin. It is the outer most or peripheral part of primary dentin and is about 20 micrometers thick.

#### Postnatal Primary Dentin

The dentin formed from the neonatal line after birth till the time the tooth assumes its occlusal position, when it is completely formed except apical root third, is known as postnatal primary dentin.

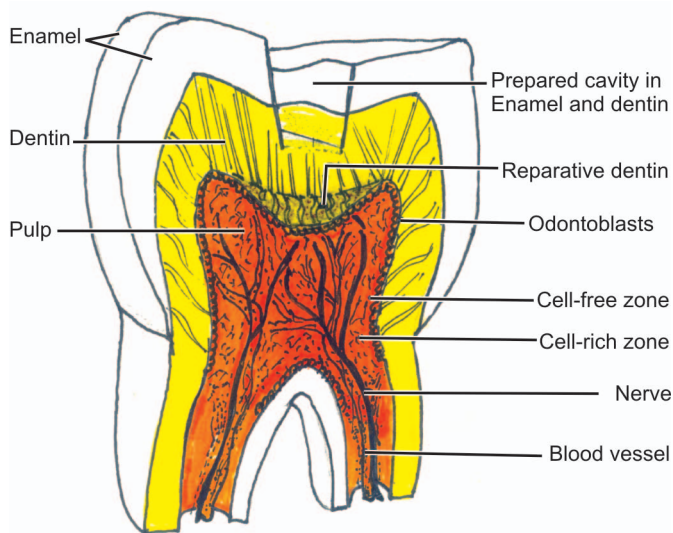
#### Circumpulpal Dentin

It forms the remaining primary dentin or bulk of the tooth. It represents all of the dentin, which is formed before root completion.

**Secondary dentin:** Secondary dentin is formed after formation of primary dentin after root completion. Its tubular direction is slightly different from primary dentin. In this, the number of tubules is less. Mostly it is formed on the floor and ceiling of pulp chamber than on sidewalls in multirrooted teeth.

**Reparative dentin:** It is also known as tertiary dentin. The secondary odontoblasts produce reparative dentin, at that wall of pulp formed due to moderate-level of irritants which act as stimulant, such as abrasion, erosion, attrition, moderate caries, trauma and some operative procedure. The secondary odontoblasts are developed from undifferentiating mesenchymal cells of pulp (Fig. 2.6).

**Sclerotic dentin:** In sclerotic dentin, peritubular dentin becomes wider and is gradually filled with calcified materials, which progress from enamel to pulp. It results



**Fig. 2.6:** Mesiodistal section of enamel, dentin and pulp showing reparative dentin formed due to deep cavity preparation. Roots shown are incomplete

from aging or mild irritation (such as slowly advancing caries) and causes a change in the composition of the primary dentin. Sclerotic dentin becomes harder, denser, less sensitive and more protective of pulp against subsequent irritations. When sclerotic dentin occurs due to aging process it is known as *physiologic sclerotic dentin* and when by irritants it is known as *reactive sclerotic dentin*.

**Eburnated dentin:** It is hard, darkened cleanable surface which is formed due to destruction by slow caries process on outward portion of reactive dentin.

**Dead tracts:** Disintegration and analysis of the distal processes of odontoblasts due to lethal stimulation of the odontoblasts results in empty dentinal tubules, which are known as dead tracts.

### Clinical Considerations

Dentin is usually distinguished from enamel during cavity preparation by the following means: (1) color (2) sound (3) hardness (4) reflectance.

Color of dentin is yellow-white or slightly darker than enamel when a fine explorer tip is moved over the enamel and dentin; enamel surfaces will provide a sharper, higher-pitched sound than dentin surfaces. Dentin is softer than enamel, hence, when explorer tip

## 14 Textbook of Operative Dentistry

is moved over enamel and dentin, more force is required on explorer for moving on dentin, because in dentin explorer tends to catch and hold in dentin. Dentin is more opaque and dull than enamel, so it reflects less light. Care should be taken to avoid exposure of exposed dentin surface to undue operative trauma, thermal changes and irritating restorative materials. Sealing of exposed dentin surface should be done with a nonirritating, insulating, preferably sedative restorative material.

Rapid penetration and spread of caries in dentin is the result of tubule system in dentin. The tubules form a passage for invading bacteria, which thus, reach pulp. The sensitivity of dentin may be explained by hydrodynamic theory that the alteration of fluid and cellular contents of dentinal tubules cause stimulation of nerve endings within these cells. By this theory, pain through dentin can be explained since fluid movement occurs throughout the dentin from dentino-enamel junction to near the pulp.

### Direct Pulp Capping

During operative procedures if healthy pulp is mechanically exposed (a) with exposure less than 1.0 mm in diameter, (b) without contamination by saliva, (c) with no damage to pulp tissue, (d) easily controlled bleeding, and (e) in young patients, it can be treated by direct pulp capping.

### Indirect Pulp Capping

The deep carious lesion, with caries very near to pulp and when there is no clinical and radiographical indication of irreversible pulpitis, can be treated by indirect pulp capping. In this, infected soft dentin is removed without exposing pulp over which calcium hydroxide or calcium trioxide layer is given. Then a layer of temporary restorative material is given, over which the cavity is properly sealed with intermediate restorative material. If tooth is symptomless, after 6 to 8 weeks temporary restorative materials are replaced by permanent restoration. Radiographic evidence of secondary dentin appears only after about 4 to 6 months. But without waiting for the radiographic evidence, to make the tooth serviceable at an early date, a permanent restoration is done because if the tooth is non-

symptomatic for 6 to 8 weeks in 99 percent of the cases, secondary dentin appears in due course of time.

Sometimes the caries may remain undetected until the pulp is infected and give rise to pulpitis leading to severe toothache. When it happens, patient is surprised about the extent of damage to the teeth without any warning of discomfort or pain. Excessive trauma or heat from operative instruments to the dentin may damage the pulp. Heat may cause dislodgment of the odontoblasts from the pulpal periphery and their “aspiration” within the dentinal tubules may take place causing pulpal damage.

### Pulp

Dental pulp is also known as the endodontium. Anatomically dental pulp is divided into two portions.

- i. Coronal pulp: It is centrally located in the crown portion of teeth.
- ii. Radicular pulp: It is located in root portion of the teeth. Pulp is continuous with periapical tissues through the apical foramen. Accessory and lateral canals also connect pulp to periodontal tissues (Fig. 2.3).

Dental pulp is composed of arteries, veins, myelinated and unmyelinated nerves, lymph channels, connective tissue cells, odontoblasts, fibroblasts, macrophages and collagen fibers. In the central area, pulp contains large blood vessels and nerve trunks. On periphery of the pulp there is a specialized odontogenic area which is made up of (1) the odontoblasts (2) the cell-free zone and (3) the cell-rich zone.

Pulp is a unique and specialized organ serving mainly four functions - (1) Nutritive, (2) Formative, (3) Protective and (4) Defensive.

### Clinical Considerations

With advancing age, the pulp chamber becomes smaller due to secondary dentin formation. Sometimes it is difficult to find out the location of root canals. Pulp stones may also cause difficulties in root canal treatment. If due to calcification pulp chamber has become smaller, proceed towards the palatal root in the upper molars to find out the opening of the pulp canal with less risk of perforating the floor of the pulp chamber. As the pulpless tooth becomes brittle, hence every effort should be made to preserve the vitality of the pulp.

## **CEMENTUM**

Cementum is bone-like calcified tissue covering the anatomical roots of teeth. It is derived from mesenchymal cells of the dental follicle that differentiate into cementoblasts. It is light yellow and slightly lighter in color than dentin. Cementum consists of approximately 45 to 50 percent inorganic materials and 50 to 55 percent organic matter and water by weight. It is softer than dentin. Sharpey's fibers, which are embedded in cementum and bone, are the principal collagenous fibers of periodontal ligament.

There are two types of cementum, acellular and cellular. Acellular cementum does not have cells and is deposited first at cementodentinal junction and covers cervical and middle thirds of roots. Cellular cementum is deposited at the apical third of root and is deposited at a greater rate than acellular cementum. Junction of cementodentin is smooth in permanent teeth.

### **Clinical Considerations**

Cementum is avascular; hence in orthodontic tooth movement it is not resorbed. It has highest amount of fluoride than other calcified tissues of body. In about 10% of teeth, cementum and enamel do not meet where dentin is exposed and cause a sensitive area. Removal of cementum covering from dentin by attrition, erosion, abrasion, caries, scaling and other procedures results into sensitive dentin for stimuli like heat, cold, sweet and sour.

## **ORAL MUCOSA**

The epithelial lining of oral cavity is called oral mucosa, which covers all other structures except clinical crowns of teeth. It is composed of two layers: (1) Stratified squamous epithelium and (2) Lamina propria. Epithelium may be orthokeratinized, parakeratinized or nonkeratinized, depending upon its location in oral cavity. Lamina propria is a connective tissue of variable thickness that supports the epithelium. It may be attached to the periosteum of the alveolar bone, or it may overlies the submucosa, which varies in different regions of mouth such as soft palate and floor of mouth.

The submucosa consists of connective tissues, varying in density and thickness and attaches mucous membrane to underlying structures. It contains glands,

blood vessels, nerves and adipose tissue. The oral mucosa is mainly of three types.

1. Masticatory mucosa (present on gingiva and hard palate), keratinized and parakeratinized.
2. Lining or reflecting mucosa (present on lip, cheek, vestibular fornix, alveolar mucosa, floor of mouth and soft palate), nonkeratinized
3. Specialised mucosa (present on dorsum of tongue)- Containing specialized glands and taste-buds.

## **MAXILLA AND MANDIBLE**

Maxilla and mandible consist of 65 percent inorganic and 35 percent organic materials.

Mandible is the heaviest and strongest bone of face. It is horse-shoe shaped and bilateral bone and forms lower jaw and is attached to the skull on both sides by a nonbony union called the temporomandibular joint. Mandible contains 10 deciduous and 16 permanent teeth in the alveolar process.

Maxilla is formed by two bones, the premaxilla and maxilla proper, which form bulk of upper jaw and major portion of the hard palate and help to form the floor of the orbit and the sides and base of the nasal cavity. Maxilla, like mandible contains 10 deciduous and 16 permanent teeth in the alveolar process.

### **Periodontium**

Periodontium invests and supports the teeth and consists of two hard and two soft oral tissues. It can be divided into: (1) gingival unit and (2) the attachment apparatus. The periodontium has mineralized tissue (bone and cementum) and soft connective tissue (lamina propria of gingiva and periodontal ligament). Periodontium is attached to the jaw by alveolar bone and to the dentin of root of tooth by cementum (Fig. 2.3).

### **Gingival Units**

It consists of gingivae and alveolar mucosa.

*Gingiva:* It consists of sulcular, free and attached gingiva.

*Alveolar mucosa:* The alveolar mucosa is a thin soft tissue that is loosely attached to the underlying alveolar bone and covered by thin, non-keratinized epithelial layer.



## ATTACHMENT APPARATUS

It consists of cementum, periodontal ligament and alveolar bone. The root of tooth is attached to bone by periodontal ligament. The periodontal ligament serves the following functions: (1) Attachment and support (2) Nutritive (3) Sensory (4) Homeostatic. Bundles of collagen fibers connect the cementum to the alveolar bone and act as a cushion to suspend and support the tooth. Sharpey's fibers are the terminal portions of principal fibers, which are embedded in the cementum and alveolar bone.

Nutritive substances are supplied by the blood vessels to the attachment apparatus. Clinically the level of the gingival sulcus and gingival attachment is an important factor in restorative dentistry. The margin of a cavity preparation should not be positioned subgingivally except in cases of caries, demand of esthetics and subgingival extension of previous restoration.

## PHYSIOLOGY OF TOOTH FORM

### A. Contours

There is small degree of convexity on buccal and lingual surfaces of all the teeth, known as contours. On facial

surfaces of all the teeth and lingual surfaces of incisors and canines, contours are present at cervical third of crown. On lingual surface of posterior teeth contours are present at the middle third of crown.

### Importance

If contour is correct, it permits and provides an adequate stimulation for supporting tissues during mastication, resulting in healthy conditions. Overcontour permits deflection of food from gingiva during mastication and causes under-stimulation of gingiva. It also permits retention of food, which causes red colored, flabby, chronically inflamed gingiva and increased plaque retention which initiates carious lesion. Under-contouring of teeth causes direct impact of food on supporting tissues, which causes trauma to them (Fig. 2.7).

Proper contouring of proximal surfaces of teeth is also important for health of investing tissues. (1) It provides proper contact of adjacent teeth at their contact point to prevent impaction of food. (2) It provides adequate gingival embrasure space for gingival tissue, supporting bone, blood vessels and nerves which serve the supporting structures.

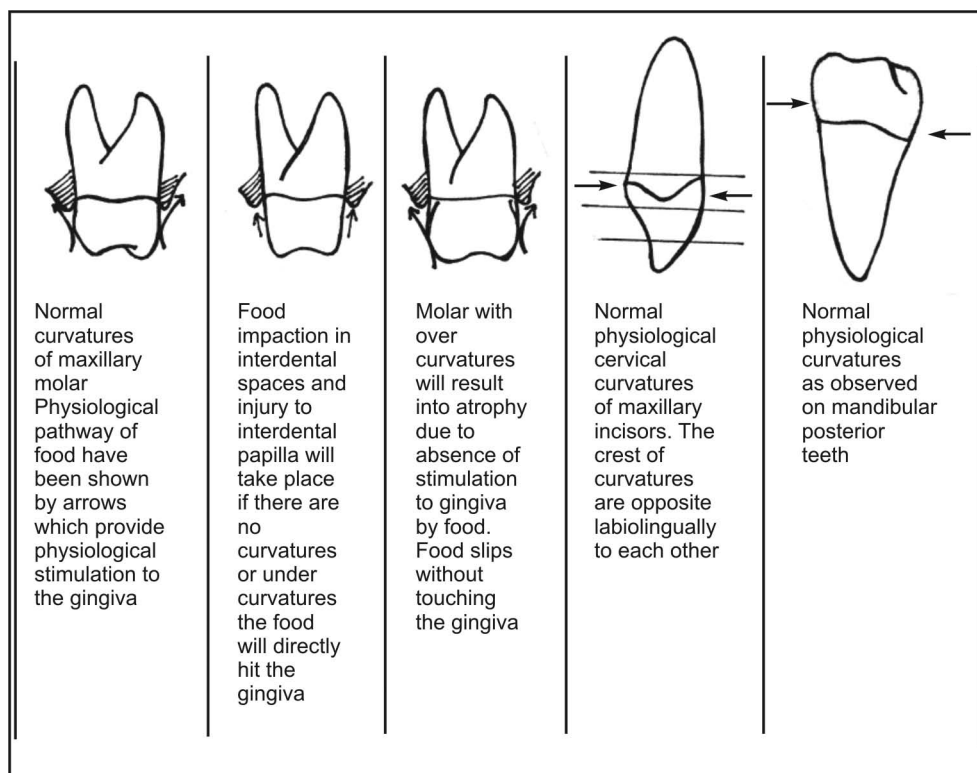


Fig. 2.7: Normal curvatures are helpful and over and under curvatures of teeth are harmful to periodontium

## **B. Functions**

Teeth perform four main functions - (1) Mastication, (2) Esthetics, (3) Speech and (4) Protection.

Proper alignment of the teeth and their normal form ensure efficiency in incising and reduction of the food. The form and alignment of the anterior teeth are important esthetically for a person's physical appearance.

The form and alignment of the anterior and the posterior teeth have a significant effect on speech. The form and alignment of the teeth also assist in development and protection of the gingival tissues and alveolar bone, which support them.

## **C. Proximal Contact Area**

When teeth erupt to make a proximal contact with adjacent erupted teeth in the same arch, initially it is by a contact point but gradually it becomes a contact area because there is wear of contact point by physiological tooth movements during mastication.

In maxillary and mandibular incisors, the contact area is located at incisal third of crowns. But when moving posteriorly in arch, contact areas are located nearly at junction of incisal and middle third, and in middle third. In faciolingual direction contact areas are not located facially from center, hence, it forms large lingual embrasure and small facial embrasure.

Physiological significance of properly located and properly formed proximal contacts is to provide normal healthy interdental papillae filling the interproximal space. The improper proximal contact is the cause of impaction of food, movement of teeth, periodontal diseases, caries and halitosis due to decomposition of retained food (Figs 2.8 to 2.11).

## **D. Embrasures**

Embrasures are spillway V-shaped spaces that originate at the proximal contact areas between adjacent teeth. There are four types of embrasures and their name is by the direction towards which they radiate: (1) Facial (2) Gingival (3) Occlusal or incisal (4) Lingual - Lingual embrasures are larger than facial embrasures, so more food is displaced lingually so that tongue can return the food to occlusal surface easily.

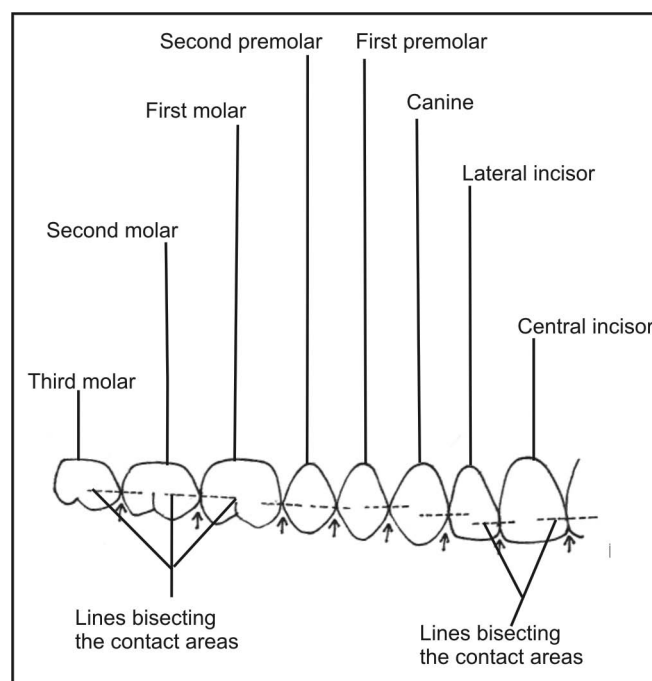
Papillae, which fill gingival embrasures of incisors and canines are triangular and in posterior teeth these are tent or mountain range shaped papillae. Crest of

papillae occurs at lingual and buccal embrasure and below contact area concavity is observed, which is known as 'col'. It is more vulnerable for bacterial infection because it is non-keratinized.

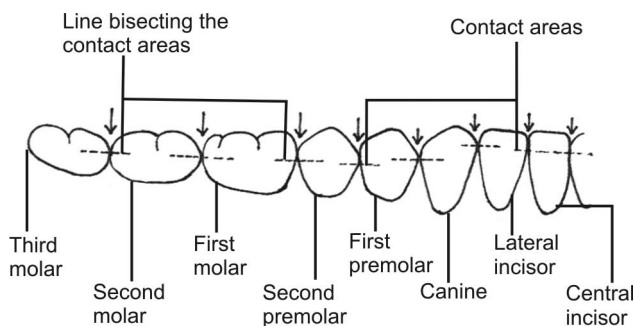
## **Clinical Considerations**

Gingival papillae prevent food impaction in gingival embrasure. The correct relationship of embrasures, cusp to sulci, marginal ridges and grooves of adjacent and opposite teeth provide for the escape of food from occlusal surfaces during mastication. If embrasures are too large they can damage the supporting tissues as food is forced into the interproximal space by the opposing cusp, and if too small or absent, additional stress is created on teeth and supporting tissues, during mastication.

Marginal ridge of posterior adjacent teeth should be at the same level for proper contact and embrasure form. If it is not at the same level it can cause problems like food impaction and injury to periodontium. Correct anatomical form of embrasure areas is necessary for self-cleaning action (Figs 2.8 to 2.11). Therefore, during restorative dentistry providing correct anatomical forms and shapes is very important.



**Fig. 2.8:** Outline drawing of maxillary teeth showing contact relationship between adjacent teeth (by broken lines). Arrows indicate the incisal/occlusal embrasure spaces. Broken lines bisecting the contact areas



**Fig. 2.9:** Outline drawing of mandibular teeth showing contact relationship between adjacent teeth (by broken lines). Arrows indicate the incisal/occlusal embrasure spaces

## TEMPOROMANDIBULAR JOINT AND TYPES OF MANDIBULAR MOVEMENTS

Temporomandibular joint is a diarthrosis joint. In temporomandibular joint, both gliding movement and a loose hinge movement take place. The osseous part of joint is glenoid fossa and articular eminence of temporal bone and condyle of mandible. The articular disc which consists of dense collagenous connective tissue is relatively avascular, hyalinized and without any nerve. It is situated between glenoid fossa and condyle and divides the joint into two compartments.

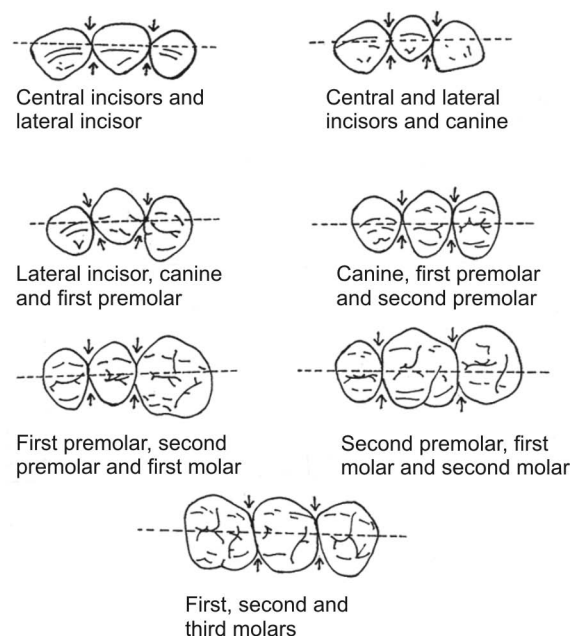
*Types of mandibular movements:* Three types of mandibular movements occur in sagittal, coronal and transverse planes.

## MANDIBULAR MOVEMENTS AND TOOTH CONTACTS

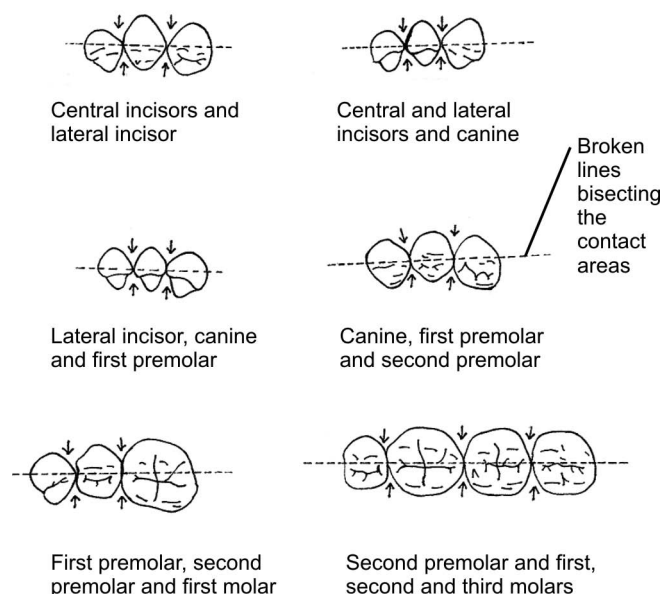
The design of restorations and choice of restorative materials must be capable of withstanding the forces of mastication and clenching, during contacts of opposing teeth. Hence, evaluation of location, direction and area of tooth contacts during various mandibular movements is an essential part of the preoperative evaluation of teeth and the restorative materials to be restored.

### Anterior Tooth Contacts

During protrusion lower anterior teeth glide along the lingual surfaces of maxillary anterior teeth. In protrusion and lateral movements multiple contacts between anterior teeth are desired because it prevents transfer



**Fig. 2.10:** Outlines of the incisal and occlusal aspects of maxillary teeth showing relative positions of the contact areas labiolingually and buccolingually. Arrows indicate the facial and lingual embrasure spaces. Broken lines bisecting the contact areas



**Fig. 2.11:** Outlines of the incisal and occlusal aspects of mandibular teeth showing contact relationship labiolingually and buccolingually. Arrows indicate the facial and lingual embrasure spaces

of total force to an individual tooth. In protrusion, posterior teeth after restoration should not come in contact because it will overload the involved tooth. The amount of posterior teeth separation depends upon combination of the anterior guidance and the slope of the articular eminence when mandible moves anteriorly. The laboratory must be provided with this information for fabrication of ceramic and cast metallic restorations so that the position and height of restored cusps can be evaluated. This will minimize the chairside time and effort required to adjust the completed restorations.

### **Posterior Tooth Contacts**

There should be no contact of occlusal surfaces of posterior teeth except at intercuspal position. The forceful contact of any cusp of posterior molar tooth during chewing and clenching will produce damaging effects on that tooth. Good restoration of posterior teeth without any introduction of undesirable tooth contacts is very difficult in case of shallow canine guidance and openbite cases. Hence, in these types of cases, articulator mounted casts are used to assess and solve these restorative problems.

In worn out dentitions, tooth contacts posterior to the canine on the working side may occur. Canine teeth shortened by wear result in decrease of separation of posterior teeth, which leads to multiple contacts of posterior teeth on working side. Multiple tooth contacts during lateral jaw movements are called group function.

Group functions have both damaging and beneficial effects. Their damaging effect is due to increased amount of torque and wear imposed on teeth closer to the muscle attachments on the mandible. Group function has beneficial effect as in case of canine where bony support is compromised by periodontal disease or in case of class II occlusion where canine guidance is impossible. Side opposite to the working side is called non-working side and normally does not contain any food bolus during chewing. During chewing closures, the mandibular teeth on the non-working side close from a medial and anterior position and approach intercuspal position by moving laterally and posteriorly.

### **CONTROL OF MASTICATION AND NEUROLOGICAL CORRELATIONS**

During all stages of mastication, manipulation and preparation of the food for swallowing, there exists a co-ordination of lips, tongue, and mandibular

movements. Chewing cycle consists of three components, opening, fast closing, and slow closing. Several types of feedback from periodontal receptors, muscle spindles and touch receptors in the skin and mucosa go to central nervous system. The slow closing component of chewing cycle is associated with the increased forces required for crushing food. This sensory feedback controls the closing of muscles of mandible due to pain. Some sensory feedback acts as excitatory for further closing and application of more force to crush food, but these must have an upper limit for inhibition, which prevents build-up of excessive occlusal force.

The group of neurons in the brain-stem produce bursts of discharges at regular intervals by excitation that drive the rhythmic chewing, and are termed the central pattern generator. The basic central pattern generator is modified by oral sensory feedback mechanism and is essential for co-ordination of the lips, tongue and mandible. The coactivation of the opening and closing muscles makes the mandible more rigid and also serves to brace the condyles while the food is crushed. For further details of this chapter consult Textbook of Dental and Oral Histology and Embryology with MCQs and Textbook of Dental and Oral Anatomy Physiology and Occlusion with MCQs by the authors.

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# 3

## *Occlusion and Operative Dentistry*

In dentistry, the term “occlusion” means the contact relationship of opposing teeth in function or parafunction. The modern concept of occlusion includes the idea of an integrated system of functional units involving teeth, joints and muscles of the head and neck. This functional complex is responsible for occlusion of teeth. The concept regarding occlusion is mainly given to clarify the condition of the occluding surfaces during restoration of a tooth. It also signifies the proximal contacts of all the teeth.

### **BIOPHYSIOLOGY OF OCCLUSION**

Mandibular movements and positions are limited by structures and functions. In restorative dentistry an effort is made to create a harmony between the structural guidance from the teeth and joints and functional control mechanisms of the neuromuscular system. The central parts of the temporomandibular joint do not get any blood supply, and they are also devoid of sensory nerve supply. They can bear the functional stress without any discomfort. During chewing and deglutition of food the prime functional force occurs in centric position. In centric position stress is felt at the center of the joint and in the axial direction of posterior teeth.

### **Cuspal Position in Centric Occlusion**

For mastication and deglutition, both occlusal and neuromuscular guidance are necessary. Centric stops are known as those areas where the surfaces of the supporting cusps make contact with the opposing tooth surfaces. The supporting cusps are lingual cusps of maxillary and buccal cusps of mandibular premolars and molars and cusp tips or incisal edges of anterior teeth. According to Angle Class I arrangement the cusps of the maxillary molars and premolars occlude in fossae or on marginal ridges of mandibular molars and premolars. These areas are known as centric stops. When adequate centric stops have not been provided on the restorations, then the alteration of chewing

pattern and bruxism may happen and it can be adapted only by structural changes.

Occlusal forces can be measured by tactile sensation at the dentogingival junction. There is individual variation between the types of teeth. This type of testing should be done prior to and after restorative procedures. All centric stops should be evaluated using thin articulating paper.

### **Adaptability**

The mandibular movements are restricted by the various surfaces of the teeth which come in contact with each other during functions and parafunctions. Restorations which are not compatible with the already present guidance may require functional or structural adaptation.

### **Centric Occlusion**

In centric occlusion there is maximum intercuspation of teeth. It is in harmony with the neuromuscular mechanism. In this, mandible is not in most retruded position and TMJ is in most comfortable unstrained position. In centric occlusion, the maxillary lingual cusps are in contact with central fossae or marginal ridges.

### **Centric Relation**

In centric relation mandibular condyles are in an unstrained position. In this position mandible is neither protruded, nor retruded nor deviated to any side. The condyles are in the most superior position they can attain in the glenoid fossa. If the temporomandibular joint is healthy and muscle functions are normal, then the patient is asked to close the mandible in retruded position. While recording centric relation the condyles should be in their midmost, uppermost unstrained and most retruded position. If there is pain, discomfort or any pathology then centric relation cannot be recorded accurately. The biophysical transverse axis of jaw movement should be equal to the mechanical axis of an articulator in order to simulate jaw movements, when

the patient is not there. The axis has to be determined accurately on a patient and transferred to an articulator. Nowadays an arbitrary hinge axis is obtained. An earpiece facebow is used, the maxillary cast is mounted on a 'semi-adjustable' articulator. Now the mandibular cast is mounted using retruded position.

Complete intercuspation is seen only when the intercuspal position and retruded position are coincident during mandibular closure. There are some occlusal contacts which prevent the maximum intercuspation while the mandible is in retruded position. These are known as premature contacts.

### Anterior Guidance

The individual anterior restoration has a guidance. This should be compatible with the already present *anterior tooth guidance*. But if all the anterior teeth are restored, the anterior guidance can be changed. But the changes should be compatible with the capacity of the neuromuscular system (Fig. 3.1).

### Lateral Guidance

It has to be considered that which guidance is optimal, whether total guidance on the canine or shared guidance between the canines and posterior teeth. However, complete control over which kind of guidance is to be used is an option usually found only when doing full mouth rehabilitation. It is not necessary to incorporate occlusal contacts on the balancing side, neither there is a need to have contact between the facial inclines of the mandibular teeth and palatal-axial surface of the maxillary molars.

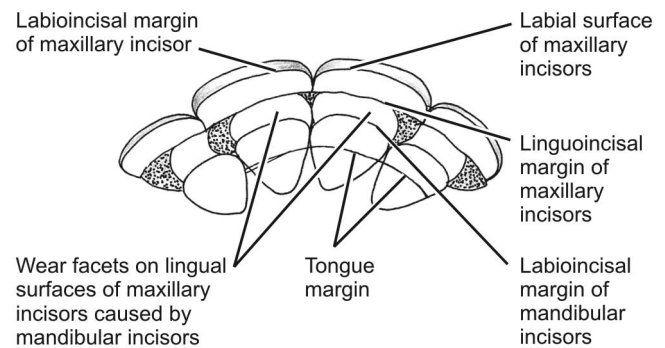
The response to failure to replace a contact may occur if guidance is shifted to an anterior tooth. A change in tooth guidance may lead to the changes in the pattern of mastication and parafunctional movements (Fig. 3.2).

## RELATION BETWEEN THE OCCLUSION AND MANDIBULAR MOVEMENTS

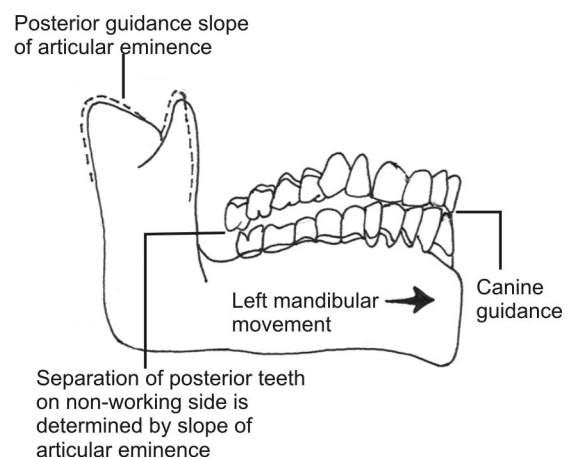
As the intercondylar distance varies, position of the teeth in relation to condyle position of the midline varies, the paths for working and balancing may change to some extent.

### Freeway Space or Interocclusal Space

It is measured when the mandible is in rest position. In different patients it varies, the position of the head is



**Fig. 3.1:** Anterior guidance as seen from chin after retracting the lower lip. During restorations care should be taken for facets caused by wear and bruxism



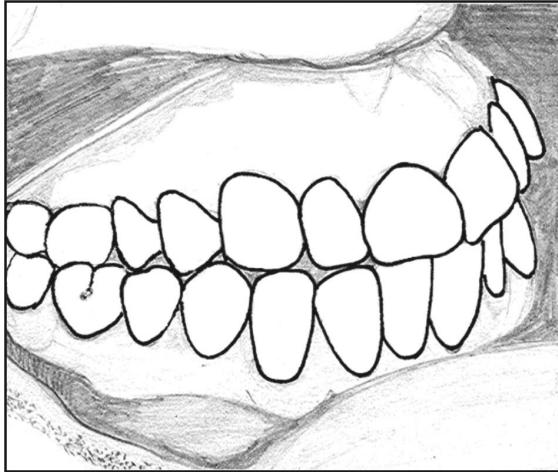
**Fig. 3.2:** Positions of teeth on balancing (non-working side) during left mandibular movement

also responsible for the variation in the measurement. While recording if the bite is raised and the interocclusal space is decreased, then the teeth will be pushed inside the jaw. If the interocclusal space is slightly more then it is better tolerated by the patient (Figs 3.3 and 3.4).

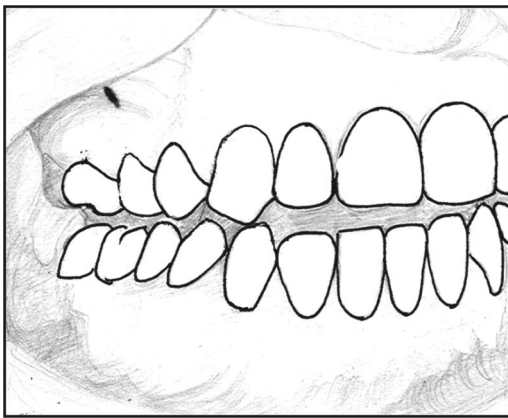
### Occlusal Stability

#### Functional/Physiological Occlusion

It is the occlusion which functions efficiently without any discomfort, pain and pathological manifestations. It is followed by the practitioners of operative dentistry and periodontists.



**Fig. 3.3:** Multiple working side contacts indicating group functions



**Fig. 3.4:** Cuspid guidance. There are no contacts of molars or premolars in right lateral movement

If there is harmony between the structural and neuromuscular components of masticatory system then a stable occlusal relationship can be obtained. The occlusal wear should be symmetrical, when the mandible closes in centric relation, the occlusal forces should be directed axially. There should be a compatible guidance relation between the teeth and joints. This determines the neuromuscular harmony. Non-functional/Non-physiological occlusion leads to discomfort, pain and trauma to periodontium, TMJ and muscles. The abnormal stress causes mobility of teeth and pushes the teeth from their position. They even apply stress towards the non-stress bearing areas of TMJ and it often leads to occlusal trauma, resorption of roots, inflammation of the temporomandibular joint, etc. It is called 'Non-physiologic occlusion'.

### Various Mandibular Movements During Function

Only preliminary knowledge about the functional movements can be obtained with the help of some devices. While chewing and swallowing tooth contact occurs. But in case of swallowing tooth contacts occur more in centric relation. Centric relation contacts are less than centric occlusion contacts. While chewing, the tooth contacts occur lateral to the centric occlusion.

Bruxism can happen if there is premature contact in swallowing. Before doing any restorative procedure the premature contacts should be corrected, because by that we can achieve a stable jaw relationship. Canine guidance simplifies restorative procedure. The centric relation should be located correctly, so that we can get an ideal occlusion. If there is harmony between the occlusal guidance and the guidance of temporomandibular joints, then the masticatory muscles will contract properly. If there is discrepancy in guidance, the muscle will not contract synchronously and neuromuscular system will also not act properly. The type of impact that shows on the muscle contraction due to occlusal interferences can be recorded by electromyography.

### RELATION BETWEEN NORMAL AND IDEAL OCCLUSION

#### Ideal Occlusion

The following are the characteristic features of an ideal occlusion.

1. When the teeth come in contact in centric relation and in centric occlusion then there should be firm and stable jaw relationship.
2. The mandible should freely move forward.
3. Soft tissue should be free of any kind of strain or trauma.
4. During various excursions gliding of occlusal contacts should occur smoothly.
5. No tooth should get any thrust either buccally or lingually during centric closure.
6. Occlusal guidance should always be on the working side.
7. There should be no restriction of the gliding between the centric relation and centric occlusion.
8. The center of the disc of the TMJ should bear even pressure on both the sides when the jaws are closed

in centric relation and the teeth are in centric occlusion.

### Explanation of Basic Occlusal Phenomenon

Radiographs and casts mounted on the articulator help in occlusal analysis. If simple restoration has to be done then it can be done in the mouth, but if multiple restorations are being done, then the articulator is used.

For occlusal analysis the following factors are considered and followed.

1. Occlusion
2. Status of the muscles and TMJ
3. Occlusal trauma, if any
4. Status of periodontium
5. Pulpal condition
6. Bruxism and Bruxomania
7. Articulation of prepared casts
8. Preparatory phase for the restoration
9. Amalgam restorations

### Occlusion

During all functional and protrusive movements if there is any premature contact or any interference it should be located. Such areas are found in the mesial inclines of the maxillary teeth, and distal inclines of the mandibular teeth.

Balancing interferences are found in the mesial or distal cusp ridge of the maxillary molars; it is also found in the buccal inclines of the lingual cusps. Teeth of balancing side should be palpated while guiding the mandible to lateral protrusive working contacts. In this way the balancing and working interferences can be ascertained (Fig. 3.5).

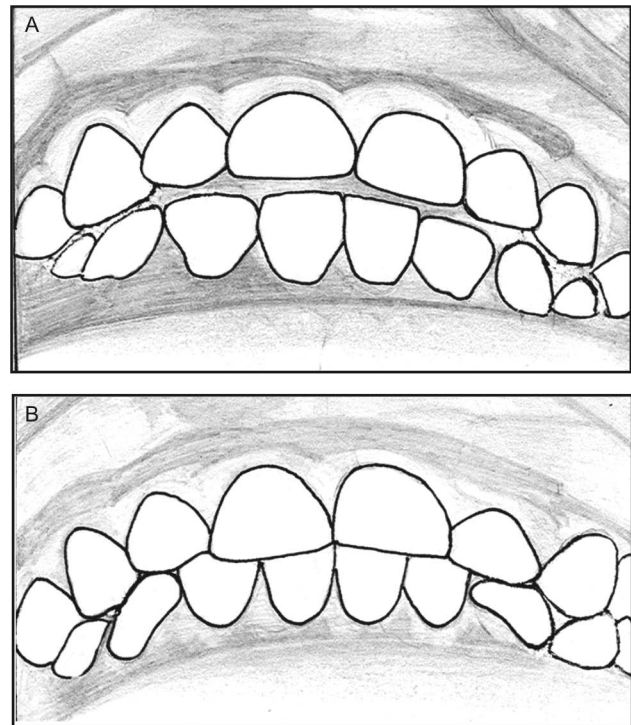
There are following working side interferences also.

1. Contacts which cause lateral tooth movement.
2. Contacts that prevent gliding on the working side.

When there is heavy occlusal trauma the facets may be present on occlusal surfaces. Working side interferences are seen in lingual inclines of the buccal cusp of upper molars.

### Status of the Muscles and TMJ

History of pain should be taken along with location, intensity and duration. If there is pain in the neck, head or in any part of craniomandibular region it should be recorded. Any surgical procedure if done should be



**Fig. 3.5:** Jaw positions and occlusal contacts between centric occlusion and centric relation. [A] Jaw in centric relation. [B] Teeth in the intercuspal position (Centric occlusion)

recorded. Mouth opening in the incisor region should be measured. The amount of lateral movement should also be measured.

In normal condition mouth opening should be more than 4 cm

In normal condition left lateral movement is 1.0 cm

In normal condition right lateral movement is 1.0 cm

Bony crepitus, clicking sound, if any, should be noted and evaluated.

During palpation of masticatory muscle, tenderness should be checked, the trigger zones, if any, should also be detected.

### Occlusal Trauma

Excessive occlusal forces lead to trauma to the periodontium. It is called as periodontal trauma from occlusion. It may lead to excessive mobility of teeth and painful ulcers.



## **24** *Textbook of Operative Dentistry*

### **Status of Periodontium**

While evaluating the status of periodontium the following conditions are examined.

- A. Condition of bone, if bone loss is there, type of bone loss, whether it is angular or horizontal.
- B. At what level the epithelium is attached to the tooth structure.
- C. If the tooth is mobile, the degree of mobility should be noted. (New Mobility Index described in 'Textbook of Preventive Dentistry' and 'Textbook of Community Dentistry with MCQs' by the authors may be referred)

The pain in the TMJ region should be differentiated with the pain present in the pulp nerves and in the periodontium.

### **Pulpal Condition**

If inflammation is present in the pulp, the pain may be referred to the temporomandibular joint. Rarely it can also cause muscle hyperactivity.

### **Bruxism and Bruxomania**

In these conditions the occlusal surfaces of the teeth are attrited and facets are seen. It is one of most important factors in TMJ/muscular dysfunction. Bruxism generally takes place during sleep. Patient is not aware of the condition and if it happens during daytime like when the patient is conscious and doing some work like driving a car, or using computer it is known as Bruxomania.

### **Articulation of Prepared Casts**

Articulation of casts is necessary for the following procedures.

- A. While making any type of indirect restorations like gold, porcelain inlays, onlays and veneers.
- B. When functional occlusal relation has to be checked.

If the casts are mounted correctly it can provide a similar occlusal contact relationship as it is inside the oral cavity.

If the articulator used has fixed condylar inclination and if it depends on tooth guidance and accepting full casts, there are chances of balancing interferences into restorations. But this can be overcome by decreasing the axial contours of upper posteriors and by avoiding balancing side contacts.

### **Preparatory Phase for the Restoration**

Before any restorative procedure all premature contacts and occlusal interferences should be corrected. This can be achieved by making centric stops and providing supporting cusps. Apart from this the other things like inclines of the triangular ridges and contours of axial wall—they should also not contact in centric. While designing the restoration the overjet, overlap and wear facets should be taken into consideration. When the amount of overlap is much greater in comparison to overjet then centric occlusion should not be disturbed, because a small amount of change can lead to TMJ muscle dysfunction.

Most of the time during protrusive and lateral protrusive excursions, interferences are seen as in case of maxillary incisors, when these teeth have been restored, because of extra quantity of material used in the lingual concavity of the incisors.

If functional disturbances are there occlusal adjustment cannot be done properly. The functional disturbances may be muscular or temporomandibular joint disorder. Muscle hyperactivity occurs due to bruxism, it can prevent the centric relation closure. This condition can be treated by using occlusal bite plate for 4 to 6 weeks. If gross dissimilarity is present between the original occlusal condition and newly achieved occlusion after restoration, then it may lead to dysfunction. The restorations should not be made on the basis of esthetics only such as, deep grooves, high cusps, but the functional requirements should be of prime concern.

If the centric stops are not adequate the teeth will show a tendency of coming out from their sockets in a direction parallel to their long axis, causing occlusal interferences. If the upper incisors and canines show high mobility, then "jiggling" of the teeth may be seen because of pressure exerted from the occlusal forces and lips. In these cases splinting can be done.

Food often gets lodged in the interproximal area present between the first and second mandibular molars. The above-mentioned phenomenon happens if contacts are not properly placed, marginal ridges are not properly created and the centric stops are not placed in proper positions. If the centric stop in the second molar is not sufficient enough this tooth will move distally after restoration of first molar. This distal movement is seen frequently because of insufficient centric stops in the adjacent marginal ridges.

The above-mentioned condition can be managed by facilitating the contact of the distolingual cusp of upper first molar with the mesial marginal ridge of the second molar. The cusp tip should never occupy the embrasure present in between the marginal ridges to prevent food lodgment.

### Amalgam Restorations

Occasionally amalgam restoration fractures at the distal marginal ridge, distal cusp ridge of the distal lingual cusp in case of lower first and second molars. The uneven marginal ridges may cause fracture in the amalgam restorations. Even if the marginal ridges are of equal height fracture may occur in amalgam restoration if the tip of the maxillary lingual cusp fits in between the two marginal ridges of mandibular molar. Biting forces should dissipate along the long axis of the teeth. So to achieve this, the occlusal stops should be provided. A centric stop for the supporting cusp should always be on a flat surface in the bottom of fossae.

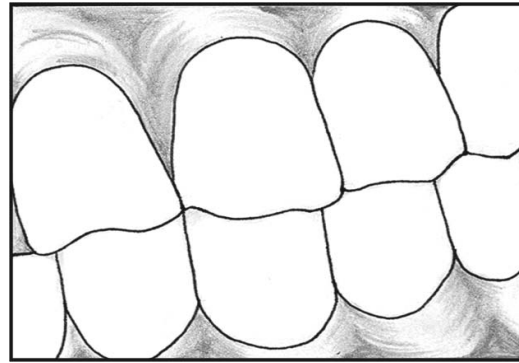
### Materials Used for Restorations

If in the upper anterior, porcelain restoration has been given it will cause uneven gradual wearing of enamel of lower anterior teeth. Most of the times it is contoured more on the lingual side, because of the displacement of the teeth anteriorly, and this causes 'jiggling' of the teeth. This will lead to occlusal trauma.

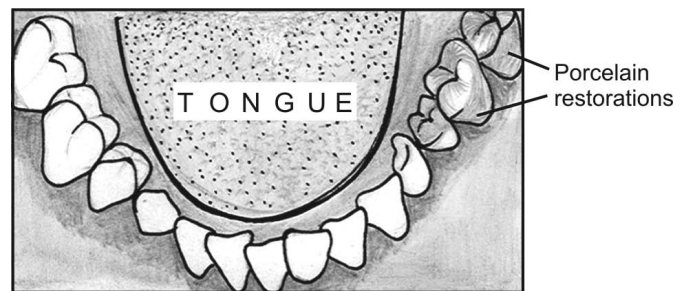
The occlusal morphology during function is very difficult to control, because occlusal forces are quite heavy, and the porcelain wears out, hence the larger thickness of porcelain is required. In some conditions the porcelain restorations are contraindicated. These conditions are as follows.

- The labio-lingual dimension of teeth are smaller.
- Patient has the habit of bruxism.
- Canine guidance is limited.
- Overjet is less.
- Overbite (overlap) is extensive.

The restored tooth, if it is involved in the disclusion mechanism, should be provided an adequate cusp height and proper cuspal inclination. This is done to facilitate the fitting in a proper sequence, timing and contact location, angulation and extent while tooth is involved in disclusion mechanism (Figs 3.6 and 3.7).



**Fig. 3.6:** Anterior guidance—protrusive edge to edge bite with facets of wear showing changed tooth contacts. Facets of wear and bruxing habits should be taken into consideration during restorations



**Fig. 3.7:** Unilateral porcelain restorations may lead to uneven wear causing occlusal instability if associated with bruxing habit

### New Concepts Regarding Occlusion and Restorative Dentistry

Recently the following concepts have been put forward.

1. The centric occlusion is situated one mm anterior to centric relation, but it has not been justified.
2. For elimination of vertical component of a discrepancy present between the centric occlusion and centric relation we do occlusal adjustment. But this also does not have a proper basis. During the treatment of TMJ/muscle dysfunction we try to correct bite of incisors.

### Occlusion in Operative Services

According to position of mandible occlusal contact patterns vary and lead to two types of occlusion—(1) static occlusion and (2) dynamic occlusion.



## 26 Textbook of Operative Dentistry

Static occlusion is defined by use of reference positions that include fully closed, terminal hinge closure, retruded, and right and left lateral extremes.

Dynamic occlusion is defined as tooth contact during mandibular movements.

There are concepts about ideal occlusion. Ideal occlusion is not observed in any person because there is wide variation in size of the jaws and arrangement of teeth within the jaws. There are variations in concept of occlusion, almost in every specialty of dentistry. The masticatory system has high adaptability, hence can function successfully over a wide range of differences in jaw size and tooth alignment. In spite of great adaptability many patients are highly sensitive to abrupt changes in tooth contacts often brought about by restorative dental procedures. In some patients minor discrepancies in vertical dimension can produce pain of temporomandibular joint, which requires correction.

The design of the restored occlusal surface has important effects on the number and location of occlusal contacts. The occlusion should be restored in both dynamic and static conditions. Therefore, the dental surgeon must understand the precise details of occlusion.

### Factors of Occlusion Affecting Operative Dentistry

#### Alignment of Teeth and Dental Arches

In both the jaws cusps are aligned in a roughly parabolic curve. The maxillary cusps are overlapping the mandibular cusps when the arches are in maximal occlusal contact because maxillary arch is usually wider and larger than mandibular arch. Two imaginary curved lines are drawn over the teeth, which help in visualization of the arch form. The alignments of similarly functioning cusps or fossae are identified by these curved lines. On the left side of arches, facial occlusion line is an imaginary line which connects the row of mandibular facial cusps. This coincides with an imaginary line connecting the maxillary central fossae. In this way on the right side maxillary lingual occlusion lines and mandibular arches central fossae lines coincide. When the mandibular arches are fully closed to maxillary arches, mandibular facial occlusion lines coincide with maxillary central fossae and the maxillary lingual occlusion line coincide with mandibular central

fossae line. On the proximal view, these lines exactly coincide.

### Interarch Tooth Relationships

The occlusal contact relationship of individual tooth in interarch can be (1) surface contact, (2) cusp and fossa apposition.

**Surface contact:** Surface contact occurs in incisor teeth. In this, incisal edge of mandibular incisor contacts lingual surface of maxillary incisors during function. This type of contact produces overlap, which is characterized by horizontal overlap or overjets, and vertical overlap or overbite. If size of maxilla and mandible is different it produces significant variations in incisor relationships. These variations are: (1) Openbite—due to mandibular deficiency and over eruption of molar teeth, (2) Crossbite—due to excessive development of mandible. During various jaw movements these variations produce significant clinical effects on the contacting relationship of posterior teeth, because the anterior teeth do not provide gliding contacts.

**Cusp and fossa apposition:** Mesiolingual cusp of maxillary first molar falls in central fossa of mandibular first molar. This relationship is important in chewing and acts as a stabilizer in alignment. The distolingual cusps of maxillary molars are in apposition to the distal triangular fossae and marginal ridge of mandibular molars and lingual cusps of maxillary premolars are appositioned with triangular fossae of mandibular premolars.

In this way, the mesiobuccal cusps of mandibular molars are in apposition to the distal fossa, or the marginal ridge bordering it and distobuccal cusps of mandibular molars are in apposition to central fossae of maxillary molars. The buccal cusp of second premolar of mandible is in apposition to mesio-occlusal fossa of the maxillary second premolar and mandibular first premolar. Buccal cusp partially occludes to maxillary first premolar and partially to maxillary canine. In case of posterior crossbite, these cusp and fossa relations are changed. Maxillary buccal cusps occlude to central fossa and marginal ridge of mandibular teeth and mandibular lingual cusps occlude to central fossae and marginal ridges of maxillary teeth.

**Characteristic features of posterior cusps:** Cusps are blunt, rounded or pointed projections of crowns of the teeth. The cusps are separated by distinct developmental grooves and have four cusp ridges or slopes which is a common feature of all the cusps. Name of cusp ridge depends upon the direction of incline of cusp. For example facial cusp ridge denotes ridge, which occurs on facial surface of cusp. The inner ridge of cusp are wider at base and narrower when they reach at cusp tip, and are named as triangular ridge. Triangular ridges are so named because the slopes of each side of ridge are inclined to resemble two sides of a triangle. These are named after the cusps to which they belong, e.g. triangular ridge of buccal cusp of mandibular molar. The presence of oblique ridge is a characteristic feature of maxillary molars. The union of the triangular ridge of the distobuccal cusp and the distal cusp ridge of the mesiolingual cusp forms it (Fig. 3.8).

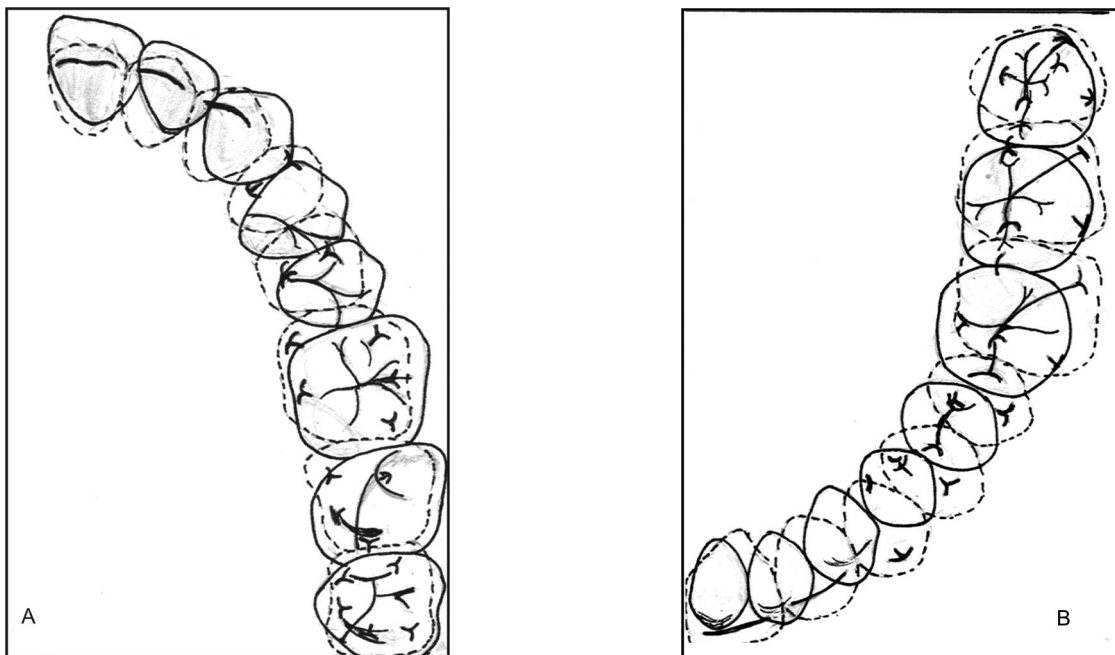
**Supporting cusps:** These are also known as stamp cusps or centric holding cusps. Lingual cusps of maxillary teeth and buccal cusps of mandibular teeth form supporting

cusps because these make contact with a centric stop on the opposing tooth. There are five common characteristic features of supporting cusps.

1. They contact the opposing tooth in centric occlusion.
2. They are nearer the faciolingual center of the tooth than non-supporting cusps.
3. They support the vertical dimension of the face.
4. Their outer incline has the potential for contact.
5. They have broader, more rounded cusp ridges than non-supporting cusps.

The relative height of supporting cusps is more than non-supporting cusps due to lingual tilt of the posterior teeth. During chewing, the maximum forces and longest duration of contact occur at centric occlusion. Drifting and passive eruption of the teeth are also prevented by supporting cusps hence they are also termed as centric holding cusps.

During restorations of the cusps, the supporting cusps should not touch the opposing tooth, because it can cause lateral deflection of tooth. The restoration should have contacts with plateaus or smoothly concave



**Fig. 3.8:** Contact relations of maxillary and mandibular teeth. (A) Maxillary teeth with dotted lines of mandibular teeth superimposed in occlusion. (B) Mandibular teeth with dotted lines of maxillary teeth superimposed in occlusion. Heavy lines within dotted outlines denote incisal ridges and summits of cusps

## 28 Textbook of Operative Dentistry

fossae so that masticatory forces are directed approximately parallel to the long axis of the tooth.

*Non-supporting cusps:* They are also called as non-centric cusps or gliding cusps or non-holding cusps. Non-supporting cusps overlap the opposing tooth without contacting the tooth and keep soft tissue such as tongue and cheek away from tooth and prevent self-injury to these soft tissues during chewing. They are buccal cusps of maxillary teeth and lingual cusps of mandibular teeth.

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# 4

## *Clinical Aspects of Dental Caries*

Cariology is a science which deals with the study of etiology, histopathology, epidemiology, diagnosis, prevention and treatment of dental caries.

### **DENTAL CARIES LESION**

#### **Definition of Dental Caries**

Dental caries is defined as a microbiological disease of the hard structure of teeth, exposed in oral cavity, that results in localized demineralization of the inorganic portion and destruction of the organic substances of the tooth, beginning on the external surface. Caries activity is highly variable, so the course of individual lesion is not always predictable. Progression of carious lesions is characterized by a series of exacerbations and remissions, because the pH at the tooth surface varies with changes in plaque metabolism.

Caries lesions are hard tissue lesions of teeth in which caries affected part is decayed. If caries occurs on tooth surface it should be removed and restored by restorative materials because enamel does not have the ability to repair affected part due to absence of ameloblasts. The prevalence of dental caries has greatly increased because of dietary changes in population. But in some developed countries incidence of caries has decreased because of preventive measures. The prevalence of tooth decay is high in developing and under developed countries.

There are following four factors which are important in caries eradication.

1. Support of a strong and efficient public health service system.
2. A potent eradicator vaccine.
3. Awareness and popular support for the program.
4. An efficient surveillance system to monitor caries control activity at a population level.

The caries eradication program has not been successful because the above mentioned basic requirements are not completely fulfilled.

### **CARIES INCIDENCE AND SUSCEPTIBILITY IN MODERN SOCIETIES**

Various studies have indicated that modern civilization and increased dental caries are constant in their association. The primitive isolated tribes are relatively caries-free. Incidence of caries also varies with various races. For examples: American blacks and whites, eating same type of food, living in the same geographical area and under similar conditions, blacks have less caries incidence than whites. Isolated tribes, eating raw and rough fibrous food remain with caries free teeth, till they start eating soft refined carbohydrate (sucrose) rich diet of modern society.

The most common epidemiological measure of caries is the DMF. Where D = diseased, M = missing, F = filled tooth; DMF may be used as DMFT which means D = diseased, M = missing, F = filled, T = number of teeth or DMFS which means D = diseased, M = missing, F = filled, S = Surfaces of teeth.

### **CARIES SUSCEPTIBILITY**

*Jaw quadrants:* Mandibular teeth are less susceptible to dental caries than maxillary teeth, because of the following reasons.

- a. The cleansing action of tongue is more in lower teeth.
- b. Collection of saliva is more in lower arch due to gravity.
- c. The buffering action of saliva in lower arch is more.

*Individual teeth:* The caries susceptibility of teeth in declining order is as follows: upper and lower first molar 95 percent, upper and lower second molar 75 percent, upper second premolar 45 percent, upper first bicuspid and lower second bicuspid 35 percent, upper central and lateral incisors 30 percent, upper cuspid and lower first bicuspid 10 percent, lower central and lateral incisors and cuspid 3 percent.

## 30 Textbook of Operative Dentistry

### Individual Tooth Surfaces

According to Hazzatt and Lotka, the caries susceptibility of individual surface of teeth is given in the Table 4.1

**Table 4.1:** Carious surfaces per 100 teeth

| Teeth            | Lingual | Buccal | Mesial | Distal | Occlusal |
|------------------|---------|--------|--------|--------|----------|
| Maxillary teeth  | 7.33    | 3.96   | 16.17  | 13.09  | 45.61    |
| Mandibular teeth | 0.73    | 11.18  | 4.96   | 4.47   | 37.98    |
| All teeth        | 4.21    | 6.93   | 10.82  | 8.98   | 41.65    |

The data indicates that occlusal surface caries is more prevalent in both deciduous and permanent dentitions. Maxillary teeth are more prone to caries than mandibular teeth. Among the proximal surfaces mesial surface is more prone to caries than distal surface and buccal surface is more prone to caries than lingual surface.

### Economic Implication of Dental Caries

There is a striking relationship between family income, education and percentage of persons visiting the dentist. The factors which are changing the economic implications of treatment of dental caries are the following.

1. Increasing economic, educational and awareness status of the population
2. Increasing esthetic consciousness
3. Commercial and social pressures
4. Insurance program
5. Increasing number of dental graduates
6. Governmental and community facilities.

### ETIOLOGY OF DENTAL CARIES

The etiological agents of dental caries are pathogenic bacterial plaque. There are two basic hypothesis concerning the pathogenicity of plaque.

1. *Non-specific plaque hypothesis:* According to this hypothesis all plaques are pathogenic because pathogenic bacteria are universally present in plaque. According to this hypothesis, the treatment of caries is total removal of plaque in all patients. But in practical life this is not possible. The antibiotic or other regimens do not have ability to eliminate plaque totally.
2. *Plaque and caries:* The carious lesions are started when specific bacteria in plaque are increased and active pH is decreased. The plaque will become

pathogenic when signs of caries develop. In 1960, Keyes and Fitzgerald demonstrated in animal models that dental caries was a transmissible infection due to presence of *Streptococcus mutans*.

### Theories of Etiology of Dental Caries

The etiological agents of dental caries are not one or two but are complicated by other indirect factors. There is no universally accepted theory of the etiology of dental caries. There are mainly three theories which are related to the etiology of dental caries - (1) Acidogenic theory (2) Proteolytic theory (3) Proteolysis-chelation theory. The fourth theory is LEVINE'S THEORY, (1977), which is mainly of academic interest. For details Textbook of Oral Pathology with MCQs may be consulted.

#### Acidogenic Theory

This theory is most accepted. All the preventive steps have been based on this theory. It was given by WD Miller in 1882. He stated: "Dental decay is a chemico-parasitic process consisting of two stages, the decalcification of enamel, which results in its total destruction and the decalcification of dentin, as a preliminary stage; followed by dissolution of the softened residue. The acid which affects this primary decalcification is derived from the fermentation of sugar lodged in the retaining centers on the surface of the teeth".

- i. *The role of carbohydrates:* The cariogenic effect of carbohydrates depends upon the following factors.
  - a. Frequency of ingestion.
  - b. Physical form (solid, semisolid, sticky jelly like, liquid form).
  - c. Chemical composition (mono and disaccharides are more carious than polysaccharides. Sucrose is most cariogenic).
  - d. Route of administration and period of contact of carbohydrate with the tooth.
  - e. Presence of other food constituents (carbohydrate is less cariogenic in presence of high fat or protein level).
- ii. *Role of microorganisms:* There are numerous microorganisms which are involved in dental caries but Streptococci and Lactobacilli are intimately related to dental caries. One or two microorganisms are involved in initiation of dental caries and others are related to progression of the caries. *Streptococcus mutans* is involved in the majority



of human carious lesions. Caries on the root surface and coronal surface shows two different dieto-bacterial interactions, and they may represent two different diseases from the ecological and microbiological point of view. Initiation of dental caries on coronal surface is caused by *Streptococcus mutans* and on root surface by *Actinomyces viscosus*. High *Lactobacillus acidophilus* count in saliva indicates the presence of more active carious lesion in the oral cavity.

- iii. **Role of acids:** The exact mechanism of carbohydrate degradation to form acids by bacteria in oral cavity is not known. For initiation of dental caries local holding of acids on tooth surface must be necessary.
- iv. **The role of the dental plaque:** The dental plaque is also called as bacterial plaque or microbial plaque. The dental plaque is essential for initiation of caries because it provides the environment for bacteria to form acid, which causes demineralization of hard tissue of teeth.

### Proteolytic Theory

According to this theory, the organic portion of teeth plays an important role in the carious process. The enamel lamellae and enamel rod sheath which are made up of organic material, are involved in the initiation of caries. In this, enamel lamellae serve as a pathway for the microorganisms, which produce acids and cause proteolysis of organic part of tooth.

### Proteolysis-Chelation Theory

This theory was proposed by Schatz. He stated that bacterial attack on the enamel, initiated by keratinolytic microorganisms, consisted of a breakdown of the protein and other organic components of enamel, chiefly keratin. This resulted in the formation of substances which may form soluble chelates with the mineralized component of the tooth and thereby decalcify the enamel at a neutral or even alkaline pH. Enamel also contains mucopolysaccharides, lipids and citrate which are susceptible to bacterial attack and act as chelators.

Reduced incidence of dental caries due to fluoridation has also been explained by proteolysis chelation theory. According to this, strength of linkage between organic and inorganic phases of enamel is

increased due to formation of fluoroapatite and thereby preventing or reducing their complexing.

### Direct Essential Local Factors Affecting the Incidence of Caries

The variation in incidence of dental caries in different individuals of same age, sex, race and geographic area, similar diet, same living conditions is due to difference in indirect or contributing factors in dental caries. There are following direct factors that influence the etiology of caries.

- A. Microorganisms (agent)-Microorganisms present, on the tooth surface like *Streptococcus mutans* and *Lactobacillus* cause dental plaque.
- B. Tooth C (Host)
  1. Morphological variation
  2. Composition
  3. Position-Tooth collection of plaque due to poor oral hygiene and dietary habits makes tooth more susceptible.
- C. Substrate (Environmental factors)
  - a. Saliva
    1. Composition
    2. Quantity
    3. pH viscosity
    4. Antibacterial factors like enzymes
  - b. Diet
    1. Physical factors
    2. Local factors
      - a. Carbohydrate content—Presence of refined cariogenic carbohydrate particles on the tooth surface
      - b. Vitamin content
      - c. Fluoride content
      - d. Fat content
- D. Time period

### Microorganisms

Microorganisms are most important factor for initiation of caries. They ferment the carbohydrates to produce acids. These acids dissolve the inorganic content of the tooth. Microorganisms present, on the tooth surface like *Streptococcus mutans* and *Lactobacillus* cause dental plaque.

### Tooth (Host) Factor

The morphological characteristics of the tooth influence the initiation of dental caries. These morphological features which predispose the tooth to development of dental caries are deep and narrow occlusal fissures, deep buccal or lingual pits and enamel hypoplasia, etc.



## 32 Textbook of Operative Dentistry

There is no difference in the chemical composition of carious and sound enamel in contents of calcium, phosphorus, magnesium and carbon, but there is difference in their fluoride content. In carious and sound enamel it is 139 ppm and 410 ppm respectively and in carious and sound dentin it is 223 ppm and 873 ppm respectively. Due to greater mineralization and accumulation of more quantities of fluoride, zinc, lead and iron on surface enamel, it becomes more caries resistant than subsurface enamel.

Tooth position also affects the initiation of dental caries. If a tooth is out of position, rotated or in any abnormal position, it becomes difficult to clean, and hence retains more food and debris.

### Substrate (Environment Factors) Mainly They are Saliva and Diet

#### Saliva Factor

Saliva has various inorganic, organic constituents and enzymes which vary from person-to-person. The inorganic component, fluoride is significant in caries prevention. Urea and ammonia are the organic components in saliva and in caries-immune person, greater content of ammonia is observed than in caries susceptible persons. Urea is hydrolyzed by urease enzyme into ammonium carbonate and it increases the neutralizing power of saliva.

The quantity of saliva secreted in a given period of time may influence caries incidence. Caries on smooth surfaces of teeth starts due to frequent use of sucrose or low salivary flow. Patients with cancer of oral cavity and jaws, who have received radiation therapy suffer from xerostomia. It causes rampant caries due to decreased saliva and increased percentage of *S. mutans* and *Lactobacilli*. In cases of salivary gland aplasia and xerostomia in which salivary flow is decreased, there is presence of more rampant caries. Therefore, the rate of flow of saliva is an important factor which helps to contribute to caries susceptibility or caries resistance.

The pH of the saliva shows definite relationship to dental caries. The viscosity of saliva depends upon the mucin content which is derived from the submaxillary, sublingual and accessory glands and its significance in caries is not clear. The viscosity of saliva varies in different individuals. Greater caries incidence is related to thick, mucinous saliva. Saliva also has antibacterial substances which prevent growth of *Lactobacilli* and *Streptococci*.

#### Diet Factors

1. *Physical nature of diet:* The primitive man used to eat rough and raw unrefined foods which had self cleansing capacity. So, caries incidence was low. But in present times, soft refined foods are eaten which cling tenaciously to the teeth and are not removed easily due to lack of roughage. Hence, it causes high incidence of dental caries.
2. *Carbohydrate content of the diet:* It is an important factor related to dental caries process. There is direct relationship between dental caries and refined carbohydrates. Sucrose is most cariogenic carbohydrate.
3. *Vitamin content of the diet:* Deficiency of certain vitamins also increases the incidence of dental caries. Vitamin A deficiency or excess are not related to dental caries. Vitamin D helps in normal development of teeth. Malformation, particularly enamel hypoplasia is due to vitamin D deficiency and causes early attack of caries. The supplement of vitamin D in children helps in the formation of healthy teeth and thereby helps in reduction in the dental caries. Vitamin K has enzyme inhibiting activity in the carbohydrate degradation cycle. But vitamin K deficiency does not affect the dental caries incidence.

Vitamin B complex deficiency may exert a caries-protective influence on the tooth. Several types of vitamin B are essential growth factors for the oral acidogenic flora which serve as component of the co-enzymes involved in glycolysis. Vitamin B<sub>6</sub> (Pyridoxin) acts as an anti-caries agent because it promotes the growth of non-cariogenic organisms which alter oral flora and suppress the cariogenic organisms. Vitamin C does not help in protection of tooth against dental caries, but it is a must for the health of the gingiva.

After tooth formation is complete there is no relation between dietary calcium and phosphorus to the incidence of dental caries. There is some evidence that calcium and phosphorus retention may be related to inactivity or arrest of dental caries.

- a. *Vanadium:* There was decrease in the incidence of dental caries in permanent teeth of those persons who lived in those areas where concentration of vanadium in drinking water was increased.

- b. *Selenium*: There was increase in the incidence of dental caries in those areas where there is high concentration of selenium in drinking water.

### Time Period

The time period during which all above three direct factors, i.e tooth, microorganisms and substrate (carbohydrate and saliva) are together should be sufficient to produce acidic pH which is essential for dissolution of enamel to produce dental caries. Time required for acid production by the fermentation of the carbohydrates by bacteria in the dental plaque, and for demineralization of tooth, is allowed by poor oral hygiene and not cleaning teeth immediately after eating (Fig. 4.1).

## Indirect Systemic Factors

### Lactation and Pregnancy

There is no direct relation between pregnancy and lactation and the incidence of dental caries. But in later stages of pregnancy or shortly after delivery, women manifest a significant increase in dental caries activity probably due to more attention to the pregnancy and infant and less attention to her own teeth.

### Heredity

Some races have high incidence of dental caries, e.g. white American and English people. Some races due to hereditary patterns have low incidence of dental caries, e.g. Indians and black Americans. There are some local factors which can easily alter the manifestation of caries activity based on heredity pattern. These are food likes and dislikes, dietary habits, cooking habits, tooth brushing frequency and its method.

## CARIES OF ENAMEL

Caries of enamel starts by deposition of microbial plaque on enamel surface. The carious process of the enamel slightly differs according to its occurrence on tooth surface, e.g. smooth surface caries, and pit and fissure caries.

### Smooth Surface Caries

After removal of dental plaque from smooth surface of tooth and drying it, the earliest manifestation of incipient

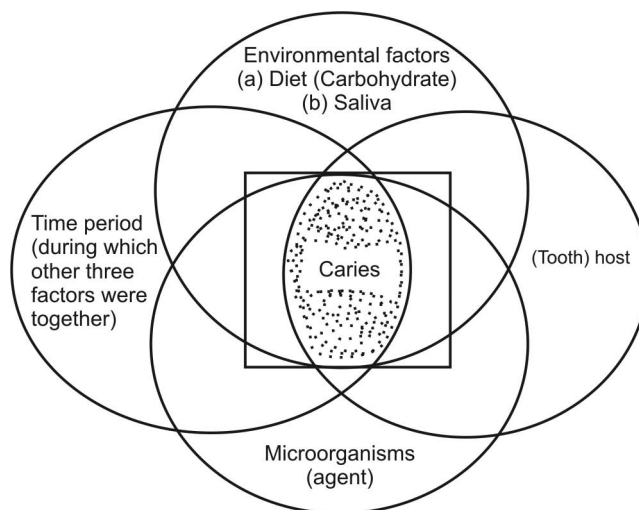


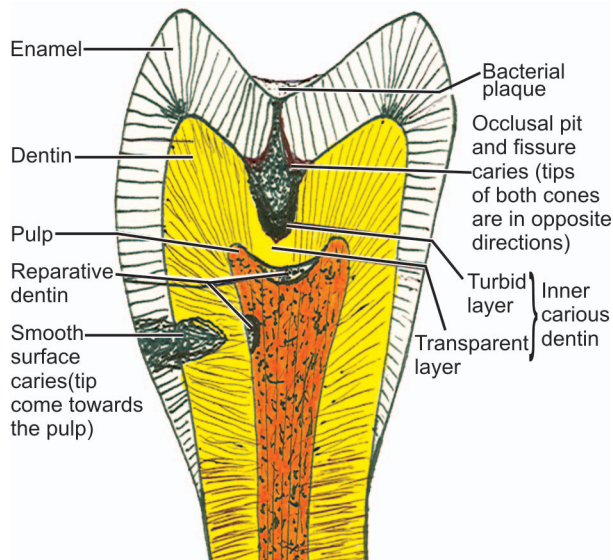
Fig. 4.1: Dental caries—Essential four factors for initiation

caries is like a smooth chalky white area. In enamel caries first change is usually a loss of the inter-prismatic or inter-rod substance of the enamel with increased prominence of the rods. The accentuation of the incremental lines of Retzius is another early change in enamel caries. The accentuation of calcification lines or incremental lines of Retzius is an optical phenomenon due to loss of minerals which causes the organic structures to appear more prominent. On the proximal surface carious lesions have cone or triangular shape, in which apex is toward the pulp and base toward the outer surface of tooth (Fig. 4.2).

1. Smooth surface caries occurs on gingival third of buccal and lingual surfaces and on proximal surfaces.
2. On proximal surface caries begins below the contact point and in early stages these appear as a faint white opacity of enamel without loss of continuity of surface.
3. As caries progresses it appears bluish-white in color.
4. Caries in the cervical area is in the form of crescent shaped cavities.
5. It appears as a slightly roughened chalky area which gradually becomes excavated.

### Pit and Fissure Caries

The faulty and non-coalesced developmental lobes of enamel in fossa form are termed as pits and fissures.



**Fig. 4.2:** Cones of pit and fissure and smooth surface caries

These structures are observed on occlusal surface of posterior teeth and buccal and lingual surfaces of molars and rarely on lingual surface of maxillary incisors. The morphology of pits and fissures is considerably variable as some pits and fissures penetrate entirely through the enamel and others open near the dentin. So, the shape of pits and fissures contributes to their high susceptibility to caries because in these structures bacteria and food debris are packed. The microorganisms ferment this food and acid is produced and caries is initiated.

### Clinical Features

1. Initially caries of pits and fissures appears brown or black in color and with a fine explorer it will feel soft and a 'catch' is felt.
2. The enamel which borders the pits and fissures appears opaque bluish-white.
3. If enamel is thin at the base of pits and fissures, it causes early involvement of dentino-enamel junction and caries spreads laterally and involves dentin. This type of progression causes undermining of enamel. This undermined enamel is sometimes fractured by masticatory forces. When bur enters through pit and fissure into this type of tooth, a large carious lesion is observed which gives the wrong idea of "internal caries". This gives a view as if the dental caries has decayed the tooth from inside to outside.

4. When undermined enamel fractures, it causes exposure of cavitation and caries.

Pit and fissure caries differs from smooth surface caries only in anatomical and histological structures. Pit and fissure caries have narrow and deep space in which apex is toward the outer surface of the tooth and base toward dentino-enamel junction. Due to this type of destruction of enamel layer caries leads to unsupported enamel rods which fracture due to masticatory forces and result in a cavitation. This type of cavitation is large in comparison to smooth surface caries. In dental caries, loss of continuity of the enamel surface occurs, and the surface feels rough to the point of an explorer (Fig. 4.2).

### Zone in Caries Lesions

In caries of enamel, several zones can be distinguished, before complete disintegration of the enamel occurs. These zones are beginning on the dentinal side of the lesion.

**Zone 1-Translucent zone**—It represents the advancing front of the enamel lesion. This zone is not always present. This is ten times more porous than sound enamel.

**Zone 2-Dark zone**—It lies adjacent and superficial to the translucent zone. It is called as dark zone because it does not transmit polarized light, and is also known as positive zone, because it is usually present. This zone is formed by demineralization because demineralization and remineralization both occur in this zone. So, this zone is 2 to 4 percent porous.

**Zone 3-Body of lesion**—It is the largest portion of the incipient caries, which lies between surface zone and dark zone. In body of lesion the stria of Retzius are well marked, which indicates that in this area more demineralization occurs and results in it being more porous, varying from 5 percent at the periphery to 25 percent at the center.

**Zone 4-Surface zone**—This zone is not or least affected by caries because it is hypermineralized and has more fluoride. The fluoride forms fluoroapatite which is more resistant to caries. It is less than 5 percent porous and its radiopacity is comparable to adjacent enamel.

### CARIES OF DENTIN

When enamel caries reaches the dentino-enamel junction it spreads rapidly along this junction laterally because it

is least resistant to caries. So, more dentinal tubules are involved by caries and show an inverted V-shape in cross-section of dentin in which base is towards dentino-enamel junction and apex is towards the pulp of tooth (Fig. 4.2).

Caries in dentin spreads more rapidly in comparison to enamel because dentin provides much less resistance to acid attack. When caries attacks the dentin, the following changes occur in dentin.

### Changes in Early Dental Caries

The slowly progressing caries causes an alteration in dentin, known as dentinal sclerosis or transparent dentin. This alteration in dentin is a reaction of vital dentinal tubules and vital pulp in which lumen of dentinal tubules is sealed by deposition of crystalline materials to prevent further penetration by microorganisms. In slowly advancing caries, formation of sclerotic dentin is more and in rapidly advancing caries its formation is minimal. When dentinal tubules are completely occluded by the mineral precipitate, section of the tooth gives a peculiar transparent appearance in transmitted light. This appearance of affected dentin is termed as transparent dentin. In transparent dentin, intertubular dentin is demineralized and lumen is filled by calcified materials, which provides softness and transparency to the dentin compared to sound dentin.

In early advancing caries, fatty degeneration of Tome's dentinal fibers and deposition of fat globules in these processes may be a predisposing factor favoring sclerosis of the tubules. In older adults, caries progression in dentin is slow than in young dentin because in older people, sclerosis of dentin occurs due to aging process.

In the earliest stages of caries when only a few tubules are involved, microorganisms may be found penetrating these tubules before there is any clinical evidence of the carious process. These microorganisms are termed as "pioneer bacteria". Each tubule which is penetrated by microorganisms has almost pure form of bacteria, e.g. one tubule may have cocci form and second adjacent to first have bacilli form.

During initiation of dental caries, microorganisms present superficially are acidogenic bacteria but in deeper layers they become proteolytic bacteria, because in deeper layers there is no more carbohydrate for metabolism of bacteria.

### Changes in Advanced Dental Caries

When carious process is advanced, decalcification of the wall of the individual tubules takes place and for some time general structure of the organic matrix is maintained. Sometimes the sheath of Neumann shows swelling and thickening at irregular intervals in the course of dentinal tubules. The diameter of dentinal tubules also increases due to packing of microorganisms. Due to the focal coalescence and breakdown of a few dentinal tubules, tiny "liquefaction foci" are formed. This term was given by Miller. This "focus" is an ovoid area of destruction, parallel to the course of the dentinal tubules and is filled with necrotic debris which tends to increase in size by expansion. So it produces compression and distortion of adjacent dentinal tubules, leading to course of dentinal tubules being bent around the "liquefaction focus".

Malacotic or soft teeth are those type of teeth in which globular dentin is more, so caries occurs rapidly in them. In softened dentin, carious process extends along the lateral branches of the tubules or along the matrix fibers which run in this direction and produce clefts. These clefts are parallel to the contour lines of the dentin and during excavation of carious dentin by hand instrument, clefts account for the manner in which carious dentin peels away in thin layer.

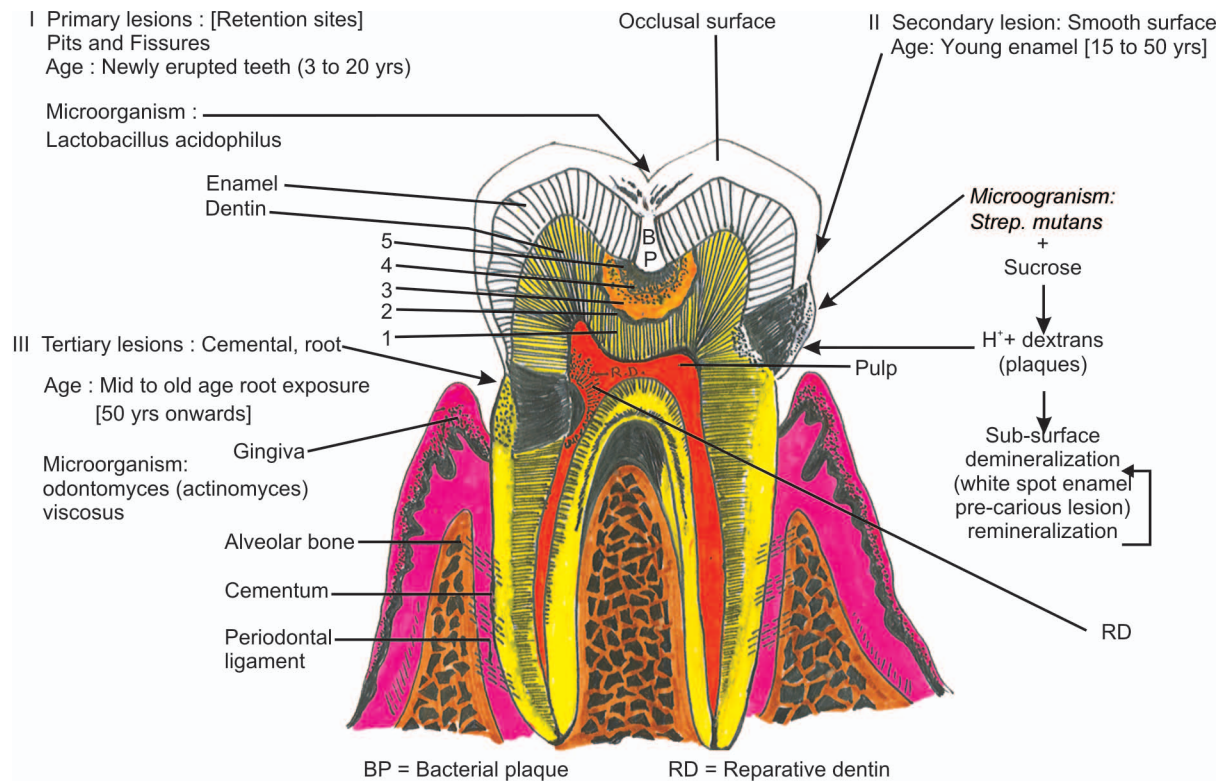
### Zones of Dental Caries

Five different zones have been described in dental caries. These zones are clearly distinguished in slowly progressing caries and less distinguished in rapidly progressing caries. These zones begin from the pulpal side (Fig. 4.3).

**Zone 1-Normal dentin**—In this zone there is fatty degeneration of Tome's fibers, otherwise dentin is normal and produces sharp pain on stimulation.

**Zone 2-Sub-transparent dentin**—In this zone inter-tubular dentin is demineralized and there is initial formation of very fine crystals in the tubular lumen at the advancing front. In this zone dentinal sclerosis, i.e. deposition of calcium salts in dentinal tubules takes place. In this zone damage to the odontoblastic zone process is evident but there are no bacteria in this zone. Hence, this zone is capable of remineralization. Dentin can produce pain on stimulation.





**Fig. 4.3:** Mesiodistal section of mandibular molar showing three types of age-related carious lesions and their causative microorganisms. Five zones of caries of dentin are also seen. Zones of carious dentin starting pulpally are (1). Normal dentin (2). Sub-transparent dentin (3). Zone of dentinal sclerosis (transparent dentin) (4). Turbid dentin (5). Outer carious decomposed dentin

### Zone 3-Zone of dentinal sclerosis (Transparent dentin)—

In this zone, deposition of calcium salts in dentinal tubules and further demineralization of intertubular dentin lead to softer than normal dentin and produce pain on stimulation. There are no bacteria present. If pulp is vital, this zone has the capacity of self-repair by remineralization of the intertubular dentin in which the intact collagen can serve as a template.

**Zone 4-Turbid dentin—**This is a bacterial invasion zone and is characterized by widening and distortion of the dentinal tubules which are filled with bacteria. In this zone, dentin is not self-repairable, because there is less mineral content and irreversibly denatured collagen. So during cavity preparation for restoration this zone should be removed.

**Zone 5-Decomposed dentin—**This is the outermost zone which consists of decomposed dentin filled with bacteria. It must be removed prior to restoration of carious tooth.

### Clinical Features of Dental Caries

The causative organisms for initiation of enamel caries are streptococci because they secrete enzyme glucosyltransferase which enhances the polymerization of the extracellular matrix and makes streptococci mutans form much tenaciously adherent colonies. Actinomyces (odontomyces) viscosus is causative organism of root caries. Lactobacilli are important in the progression of dentinal caries because of their acidogenic potential.

## CLINICAL CLASSIFICATION OF DENTAL CARIES

Dental caries may be classified according to the following.

- A. The surface topography and environmental conditions. There are four distinct clinical sites for caries initiation, accordingly they are known as follows
  1. Pits and fissures caries
  2. Smooth enamel surface caries
  3. Root surface caries
  4. Cervical caries – It starts from cervical region of the tooth.
- B. The rapidity of the caries progress, it is classified as follows.

- a. *Acute dental caries*—Acute caries travels towards the pulp at a very fast speed.
- b. *Rampant caries*—Rampant caries is a suddenly appearing, rapidly burrowing type of caries resulting in early pulp involvement, in which more than 10 new lesions appear every year on healthy teeth surfaces which are generally immune to caries.

Rampant caries is of following three types:

- *Nursing bottle rampant caries*: Infants sleep with the nipple of the nursing bottle, containing milk and sugar or a sugar containing beverage in their mouths. The child falls asleep, and the sweetened milk or liquid becomes pooled around maxillary anterior teeth. The sugar containing liquid provides an excellent culture medium for acidogenic microorganisms. During sleep the drinking and swallowing process is very much slowed down and salivary flow is also decreased. The clearance of the liquid from the oral cavity is very much slowed, resulting in rampant caries. This gives rise to multiple carious lesions on immune surfaces. This type of rampant caries is very common in infants (Fig. 4.4).
- *Adolescent rampant caries*: When rampant caries occurs in adolescent age it is called adolescent rampant caries. During adolescence some children habitually put chocolates and toffees, etc. in their mouths and go to sleep. Such children usually suffer from adolescent rampant caries.
- *Xerostomia induced rampant caries (radiation rampant caries)*: Xerostomia means dry mouth. It has been commonly observed that after radiotherapy of malignant areas of, or near the,



**Fig. 4.4:** Nursing bottle rampant caries showing infected root stumps of maxillary anterior teeth and carious posterior teeth

salivary glands, the salivary flow is very much reduced. This results in rampant caries, even in those teeth which were free from caries, before radiotherapy.

- c. *Chronic dental caries*—Chronic caries travels very slowly towards the pulp.
- C. Whether caries attacks previously intact surface or margin of restoration, it is classified as follows.
  1. Primary caries
  2. Secondary or recurrent caries
- D. The proximity of caries to pulp

Black and others have classified the cavities according to their location. For the treatment planning and prognosis the classification of caries according to its proximity to the pulp is very important and useful. This classification has been described in Chapter 8.

## ACUTE CARIES

This type of caries leads a rapid clinical course towards the pulp and results in early pulp involvement by carious process. Due to open and large dentinal tubules and absence of sclerosis in children and young adults, it mostly involves young age group. In acute dental caries, entrance is small, hence acid which is produced by bacteria is not easily neutralized by saliva, which leads to rapid progression of caries.

Pain is a common feature of acute caries than chronic caries. Nursing bottle caries is an example of acute dental caries which is also known as 'baby bottle syndrome' or



## 38 Textbook of Operative Dentistry

'bottle mouth syndrome'. For details refer 'Textbook of Pedodontics with 500 MCQs' by the authors.

### Characteristic Feature of Rampant Nursing Bottle Caries

It is observed in bottle fed infants (Fig. 4.4).

1. It occurs usually in deciduous dentition.
2. It affects maxillary four incisors, then molars followed by canines
3. It does not affect mandibular teeth.
4. Due to severe carious process only root stumps remain.

### Chronic Caries

This type of caries progresses slowly and tends to involve the pulp much later than acute caries. It is most common in adults. Due to slow progression of caries process there is sufficient time for sclerosis of dentin and formation of reparative response to the adverse irritation. In chronic dental caries, entrance is larger so less food is retained and acids which are produced by microorganisms are neutralized by saliva. Usually there is no or less pain in chronic caries because there is sufficient time for pulp to protect itself by sclerosis and formation of reparative dentin.

### Secondary (Recurrent) Caries

Secondary caries is defined as that type of caries which occurs at the margins of a restoration. The causes of secondary caries are poor adaptability of restorative materials to the cavity walls and leaky margins or inadequate extension of restorative materials to margin of cavity, which favour the retention of food debris and bacteria.

If restorative material adequately seals the inter-surface of cavity wall and restoration, there is no further spread of caries around the restoration. If leakage is present between inter-surface, carbohydrate and bacteria enter in inter-surface space and cause secondary caries (Fig. 4.5).

### Arrested Caries

This type of caries is relatively uncommon and does not have any tendency for further progression because it becomes static or stationary. It occurs in both deciduous and permanent dentition. Arrested caries occurs on occlusal and proximal surfaces and is characterized by

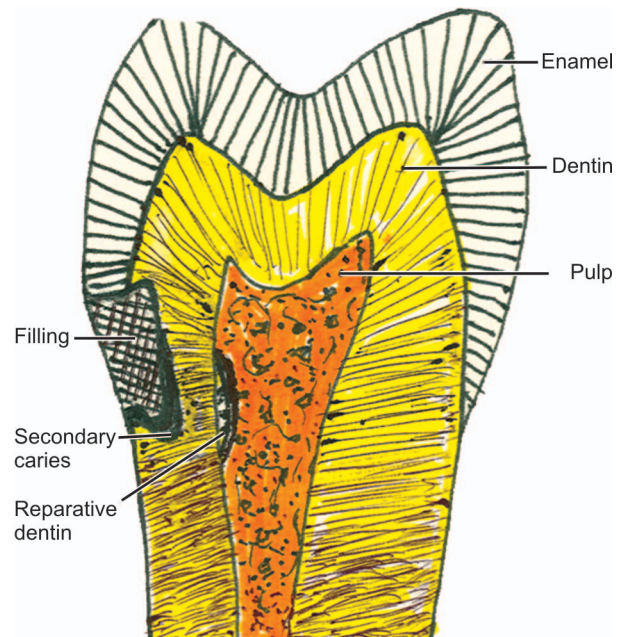


Fig. 4.5: Secondary (Recurrent) caries

a large open cavity which no longer retains food and becomes self-cleansing. Arrested caries on the proximal surface of tooth occurs due to extraction of adjacent tooth. It appears as brown-stained area just below contact point of retained tooth. The caries process is arrested due to area of proximal surface becoming self cleansing because of extraction of adjacent teeth. In these cavities, superficially softened and decalcified dentin is gradually burnished away due to mastication until it takes on a brown stained, polished appearance which is hard. This type of dentin is referred as "eburnation dentin".

### DIAGNOSIS OF CARIES

Stedman's medical dictionary 27th edition has defined diagnosis as, the determination of the nature of a disease, injury, or congenital defect. Taber's medical dictionary 18th edition has defined diagnosis as the term denoting the disease or syndrome a person has or is believed to have.

The diagnosis is defined as the correct determination of disease by discriminative estimation and logical appraisal of conditions found during the examination, as evidenced by distinctive signs and symptoms. In its early stage caries is diagnosed by presence of cavitation on the tooth surface. The primary aim of effective

diagnosis and treatment planning is early detection of incipient caries and interception of caries process before significant amount of tooth destruction takes place. In diagnosis of carious lesion, extension of multiple tests is used because single test may not be sufficient for accurate diagnosis. Caries susceptibility differs in each individual because it depends on food habits, age, sex, heredity, geographical origin, ethnic background, and fluoride exposure.

### Methods of Diagnosis of Caries

Early diagnosis of the caries is very important. Following methods are used for the diagnosis of caries.

*Visual inspection methods:* In this careful inspection with sharp explorers of proper shapes for cavitations, surface roughness, opacification and discoloration is done. The teeth are cleaned, dried with mild compressed air and very well illuminated for inspection. For inspections following instruments, devices and techniques are used.

1. **MAGNIFYING MOUTH MIRROR**—It shows two to three times magnified image.
2. **MAGNIFYING LENS**—It is also used to directly examine the tooth. It gives upto five times magnified image. It cannot be used on all surfaces of the tooth.

## SPECIAL ILLUMINATIONS AND TECHNIQUES

### Ultraviolet Illumination

Ultraviolet (UV) light increases optical contrast between carious area and the surrounding healthy tissue. The natural fluorescence of enamel as seen under UV light is decreased in the areas of less mineral content such as, carious lesion, artificial demineralization and developmental defects.

*Advantage*—UV illumination is more sensitive and gives more reliable results than visual and tactile methods.

*Disadvantage*—Carious lesion and developmental defect cannot be distinguished by UV illumination.

### Fiberoptic Transillumination (FOTI)

Fiberoptic transillumination (FOTI) is based on the principle that since a carious lesion has a lowered index of light transmission it appears as darker shadow. Light is delivered via fiberoptics from a light source on the

surface of the tooth. The light travels from the fiber illumination across tooth tissue to non-illuminated surface. This results in image formation which is used for diagnosis. A camera can be used to store the image for permanent record.

### Advantages

- A. Lesions which cannot be diagnosed radiographically can be diagnosed
- B. No radiation hazard
- C. Comfortable to patient
- D. Results are immediately and directly seen
- E. Photographs for permanent record can be obtained.

### Disadvantages

- A. FOTI is not possible in all locations of carious lesions
- B. There may be considerable intra- and inter-observer variations

### Wavelength Dependent FOTI

The distance light travels through tooth material from the light source to the detector is called 'effective decatic optical thickness'. It is dependent on the wavelength of light. In small lesions, the effective decatic optical thickness increases linearly with mineral loss.

### Advantages

- A. It gives quantitative information about depth of the lesion
- B. There is no radiation hazard.

### Disadvantages

Same as with FOTI.

### Digital Imaging FOTI

It works on basis of the principle that the images of teeth obtained through visible light fiberoptic transillumination (FOTI) are acquired with digital CCD camera and sent to a computer for analysis with dedicated algorithms. The algorithms are dedicated to facilitate the location and diagnosis characterization for monitoring of the lesions.

*Advantage:* It is more sensitive and reliable than routine radiography.

### Dyes

Various dyes are used for the detection of caries.

## 40 Textbook of Operative Dentistry

### Detection of Carious Enamel by Dyes

The following dyes are very useful for detection of caries.

- A. *Calcein*—Calcein dye remains in the lesion as it makes a complex with calcium.
- B. *Procion*—Procion dye reacts with nitrogen and hydroxyl group of enamel and acts as a fixative.
- C. *Brilliant blue*—Brilliant blue dye increases the diagnostic quality of fiberoptic transillumination. Some dyes irreversibly stain the enamel.

### Detection of Carious Dentin by Dyes

Dyes are used to differentiate between affected and infected dentin.

- a. *Basic fuchsin*: Half percent basic fuchsin in propyl glycol is used to stain the infected dentin. It does not stain the affected dentin. It has been reported to have carcinogenic potential. Hence, it is not commonly used
- b. *Acid red*: One percent acid red in propylene glycol is used in the diagnosis of carious dentin. It stains the infected dentin. Due to its acidic pH it cannot be used in lesions close to pulp.

### Endoscope Technique

Endoscope technique is based on observing the fluorescence which takes place when the tooth is illuminated with blue light in the wavelength range of 400 to 500 nm. Sound enamel and carious enamel produce different fluorescence. A camera can be used to store the image. If a camera is integrated with endoscope it is called a 'videoscope'.

### TACTILE METHOD

In tactile method smoothness, roughness and softness is determined by sharp explorers of various shapes. The penetration of the explorer in the tooth surface and resistance to the removal of the explorer tip have been interpreted as demineralization.

#### Advantage

This is very simple, easy, quick and inexpensive method of caries detection.

#### Disadvantages

- a. The explorer tip can spread the microorganisms from one place to another place on the surface of a tooth,

from one tooth to the another tooth and from one quadrant to another quadrant.

- b. The explorer can produce irreversible traumatic defects in remineralizable enamel.
- c. The explorer may be caught in other defects like pit and fissure instead of caries and may lead to false diagnosis.

### RADIOGRAPHIC METHODS

The following types of radiographs are useful in detection of caries.

1. *Intraoral periapical radiographs*: They are useful to view the complete tooth with supporting structures. With paralleling technique detection of caries is better than with bisecting technique of taking radiographs.
2. *Bitewing radiographs*: They provide good view of the following.
  - a. Interproximal caries
  - b. Recurrent caries
  - c. Recurrent or secondary caries below proximal restoration
  - d. Alveolar crest
  - e. Both maxillary and mandibular teeth in one film.

### Developments in Radiography

The following developments in radiographic methods are very useful in diagnosis and detection of caries.

#### Xeroradiography

In this the latent images are recorded on an aluminium plate coated with selenium particles. The latent images are developed in the positive images. They produce good details which are comparable to E-speed film.

#### Digital Imaging

By application of computer technology to radiography, image acquisition, manipulation, storage, and transmission to remote sites in a digital format is possible. Digital imaging requires electronic sensor or detector, an analog to digital converter, a computer and a monitor to display and printer to print the image.

*Direct digital imaging*—In this radiation rays are directly collected by digital image receptor.

*Indirect digital imaging*—In this video camera forms digital image of radiographs.

### Subtraction Radiography

By this technique structured radiographic noise is reduced in order to increase the detectability of changes in the radiographic pattern. Subtraction radiography is superior to conventional radiography for detecting recurrent caries, progress of remineralization patterns of dentinal caries. The visual examination of standard radiographs cannot detect a 0.85 mm change in the thickness of cortical bone, digital subtraction radiography is so sensitive it can detect a 0.12 mm change. For details Textbook of Dental Radiology with MCQs may be referred.

### ELECTRICAL CONDUCTANCE MEASUREMENT METHOD

Due to high mineralization sound enamel is very bad conductor. Increased porosity is caused by caries. Saliva fills these pores and provides conductive pathways for electric current. Hence electric conductivity is directly proportional to the amount of demineralization present.

### VANGUARD ELECTRONIC CARIES DETECTOR

It measures the electric conductivity numerically on a scale 0 to 9. Zero shows sound tooth, 9 shows high degree of demineralization.

#### Advantages

- Useful in monitoring the progress of caries
- Very effective in detecting early pit and fissure caries.

#### Disadvantage

Diagnosis can only be done in the areas where probe can reach.

### ELECTRONIC CARIES MONITOR

It is a specialized device which detects caries and can screen whole of the occlusal surface for caries by covering the surface with a conducting medium before placing a probe tip.

### LASERS

Following types of lasers are used for diagnosis of caries.

#### Diagnodent

Diagnodent is a diode-laser caries detector. It can be used to determine the soundness of tooth structure on occlusal surfaces. The caries induced changes in teeth lead to

increase fluorescence at specific excitation wavelengths. The signal appears as a number on the device on a scale of 0 to 99. The higher the number the more is the caries.

| Reading      | Conclusion      |
|--------------|-----------------|
| 00 to 13     | No caries       |
| 14 to 20     | Enamel caries   |
| More than 20 | Dentinal caries |

#### Advantages

- Early caries lesions can be detected
- On smooth surface caries detection and quantification can be done.

#### Disadvantage

Secondary caries adjacent to restoration cannot be detected by diagnodent. For details Textbook of Pedodontics with 500 MCQs may be referred.

### Quantitative Laser Fluorescence (QLF)

In quantitative laser fluorescence (QLF) argon laser (488 nm-filtered blue light source) is used. It can monitor caries lesions. The image can be stored, measured and quantified in terms of shape and area.

### Dye Enhanced Laser Fluorescence (DELFL)

It is based on the hypothesis that if a fluorescent dye penetrates on early carious lesion, current laser fluorescence method for detection and quantification of early mineral loss could be enhanced.

#### Advantages

- When plaque is absent DELFL is a better diagnostic tool than QLF for detection of demineralization.
- Optical measurement of dye uptake may be useful technique to detect approximal subsurface caries.

### Optical Coherence Tomography (OCT)

In OCT cross sectional images of biological tissues are created using differences in the reflection of light. It does not produce any adverse effect on the biological tissues.

#### Advantages

- It is potentially more sensitive method for detection of recurrent caries.
- It also shows extent and severity of the carious lesion.



## 42 Textbook of Operative Dentistry

### Confocal Laser Scanning Microscopy (CLSM)

In CLSM Ar<sup>+</sup> and Kr<sup>+</sup> laser along with appropriate set of filters are used. This combination provides a sharp and clear image. The focal plane of illumination is the same as focal plane of detection, hence they are called 'confocal'.

### DNA Chip Technology (DNACT)

Both the computer and molecular biology have very much facilitated progress in dentistry. DNACT is a new system which combines these two technologies and has potential diagnostic value in dentistry. In oral cavity saliva shows potential as a convenient substitute for blood in diagnostic testing for systemic and oral diseases.

1. Inspection, radiographic and dye uptake methods—By these methods sub-surface demineralization is identified.
2. Assessment of environmental conditions such as pH, salivary flow and buffering action of saliva.
3. Bacterial activity testing.

### Diagnosis of Pits and Fissure Caries

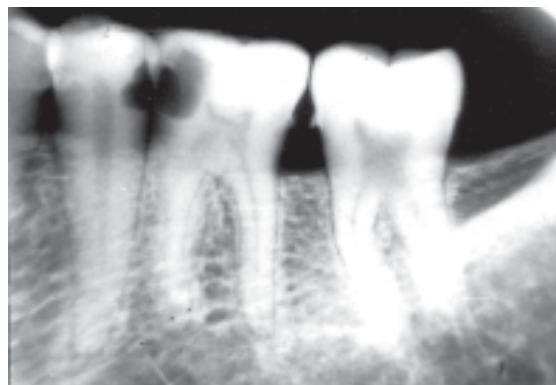
Pits and fissure caries can be detected by explorer. The cavitation at the base of a pit and fissure sometimes can be detected by tactile sensation as softness or by catching of the explorer tip. Explorer tip catching test, for diagnosis of caries is influenced by the following factors.

- i. Sharpness of explorer tip
- ii. Narrowness and depth of pits and fissures
- iii. Force applied on explorer.

Undermining of enamel around pit and fissure takes place due to lateral spread of caries at dentino-enamel junction. Clinically it appears as a brown grey discoloration that radiates away from the base of pit and fissure. On radiograph it appears as demineralization at dentino-enamel junction (Figs 4.6 and 4.7).

### Diagnosis of Smooth Surface Caries

Proximal surface caries in initial stages is best detected by bitewing radiograph because it is usually skipped during routine examination with mouth-mirror and explorer. On bitewing radiograph, it appears like triangular radiolucency at proximal surface. Careful probing with a sharp explorer may detect cavitation on the proximal surface. Brown spots on irregular proximal surface is a characteristic clinical feature of caries (Figs 4.3, 4.6 and 4.7).



**Fig. 4.6:** Smooth surface proximal caries  
(Courtesy: Dr Neelum Mittal, Varanasi)



**Fig. 4.7:** Smooth surface caries on distal surface of second molar with periapical pathology due to impacted third molar

### Diagnosis of Root Surface Caries

Root surface caries can be diagnosed visually and by tactile sensation. Visually it appears as discoloration and tactilely it feels like cavitations with rough surface of root by an explorer (Fig. 4.3).

### Caries Activity Tests

Caries activity tests are important in individual persons to help the practitioner arrive at decisions in relation to preventing and controlling measures, the timing of recall appointments, indication of type of restorative procedures and materials, and assessing the prognosis. It also helps in motivation of patients and determining the compliance after treatment regimens.

But single caries activity test is not reliable to predict the high caries risk in individuals. The principles of different caries activity tests are given in Table 4.2.



**Table 4.2:** Caries activity tests and their principles

| Test                             | Principles and results                                                                       |
|----------------------------------|----------------------------------------------------------------------------------------------|
| 1. Buffering capacity            | To estimate buffering capacity, a saliva sample is used.                                     |
| 2. Fosdick                       | Capacity of saliva sample to dissolve powdered enamel is measured.                           |
| 3. Dewar                         |                                                                                              |
| 4. Lactobacillus count           | By counting colonies on a culture media plate the number of bacteria in saliva is estimated. |
| 5. Snyder                        | In culture media the rapidity of acid formation from a saliva sample is measured.            |
| 6. Mutans streptococci screening | By use of selective culture media the number of colony forming bacteria are estimated.       |
| 7. Reductase                     | From a saliva sample, activity of reductase enzyme to change the color is measured.          |
| 8. Rickles                       | The rapidity of acid formation from a saliva sample in culture media is measured.            |

## PREVENTION AND CONTROL OF CARIES

At present time, prevention of dental caries is an important challenge for dental profession as complete prevention of plaque is not practical. If incipient caries is not diagnosed, it causes deep cavitation which provides retention of more food debris and bacteria. This is controlled by removal of carious part and restoration by effective restorative materials in physiological, functional and esthetic harmony. Caries can be prevented by three methods.

### Chemical Method

There are a number of chemical substances which are used in prevention of dental caries.

- A. **Fluoride:** Fluoride alters the tooth surface or/and tooth structure to increase resistance to demineralization and prevent dental caries. Fluorides are used in the following forms in the prevention of dental caries.
  - a. **Fluoridation of water supplies**—It is most effective form of prevention of dental caries at community level.
  - b. **Topical application of fluoride**—Fluoride is topically applied by dental professionals in the clinic and by

patient at home. There are following fluoride preparations for topical use.

1. Sodium fluoride (NaF)
  2. Stannous fluoride ( $\text{SnF}_2$ )
  3. Acidulated fluoride-phosphate
  4. Prophylactic paste
  5. Fluoride dentifrices
  6. Fluoride mouthwashes or rinses.
- B. Chlorhexidine and alexidine
  - C. Silver nitrate
  - D. Zinc chloride
  - E. Caries vaccine
  - F. **Vitamin K and sarcoside**—These substances act by interfering with the carbohydrate degradation through enzymatic alterations.

### Dietary Method

Caries can be prevented by the restriction of intake of refined carbohydrate. Sucrose is most cariogenic carbohydrate, hence its use in food should be restricted.

### Mechanical Methods

On the tooth surface, if microorganisms and food substances do not accumulate for longer period, there cannot be caries. For prevention of dental caries, there are numerous means used mechanically, in cleaning tooth surface. The following are the important means used.

- a. Tooth brushing
- b. Dental floss or tooth picks
- c. Mouth rinsing
- d. Mouth irrigation
- e. Oral prophylaxis by dental professionals
- f. Detergent food
- g. Pit and fissure sealants.

(For details, please consult Textbook of Preventive Dentistry and Textbook of Pedodontics with 500 MCQs by the Authors).

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## 44 Textbook of Operative Dentistry

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# 5

## *Patient Evaluation, Diagnosis and Treatment Planning*

Proper treatment and patient satisfaction depend upon thorough clinical history, examination and diagnostic aids. They lead to best treatment plan, hence before starting patient treatment clinician should collect all the facts associated with the problem. Usually the dental problems are not alike in two patients, they vary from individual to individual. This increases the challenge to oral diagnosis and treatment planning. For individual patient the proper examination, evaluation and diagnosis guide the effective treatment plan. The treatment plan is a complete, simple and logical sequence that guides the patient care program. The treatment plan is also used to schedule the appointments and determine the fees. All the information of the patient should be recorded accurately in record sheets for individual patients. Thus, a concise and thorough record is maintained for each patient, which is essential for proper patient care and for medical, legal and forensic purposes. Pretreatment considerations include patient evaluation, chief complaint and dental history, examination, diagnosis and treatment planning.

### **PATIENT EVALUATION**

#### **Chief Complaint and Dental History**

The chief complaint of the patient is very important as the overall treatment plan revolves around the chief complaint. The patient should be asked for available dental radiograph which will further help us in making a diagnosis and an effective treatment plan. If no or old X-rays are available fresh X-ray may be advised. A dental history should include the information about past dental problems and treatment along with the current dental problems. Thus, for an accurate treatment plan, dental history should include the following.

- a. Frequency of patient's visit to dental clinic
- b. Frequency of professional dental prophylaxis
- c. Reaction of local anesthetic or any other drug, if any
- d. History of extractions and complications
- e. Other past dental treatment.

Patient evaluation should also include infection control, review of medical conditions, sociological and psychological conditions, review of dental conditions and risk assessment of the patient.

#### **Medical History**

A knowledge of medical history permits more effective treatment planning. For a proper medical history, emphasis should be laid on the following:

1. Allergies and medications
2. Control of infection and communicable diseases
3. Systemic diseases
4. Physiological changes associated with aging.

#### **Allergies or Medication**

If the patient is sensitive to local anesthetic, during dental treatment, he/she may go in the state of anaphylactic shock. Allergic reactions may occur in the form of itching, rashes, swellings, gingivitis, ulcers, etc.

The effect of various medicaments should also be evaluated as they can alter the salivary flow, interfere with the metabolism of the other drugs and may cause the pigmentation of oral soft tissues. For example-tricyclic antidepressants make the patient sensitive to epinephrine, anti-epileptic agents may cause gingival enlargement and certain antibiotics and anti-tubercular drugs may reduce the efficacy of oral contraceptives.

### **Control of Infection and Communicable Diseases**

It plays a significant role in assessing the condition of a patient because of increasing incidence of AIDS and hepatitis B and C, so that proper measures can be taken. The evaluation of communicable diseases should be done carefully as these can affect the management of the patient and can be transmissible through the dental setting to the practitioner and dental auxiliaries. The status of immunocompromised patient should be evaluated as they are more prone to suffer from various bacterial, fungal and viral infections due to suppression of immune response.

### **Systemic Diseases**

They can affect the treatment plan as the patients with valvular defects or heart murmurs are at high risk for development of bacterial endocarditis after surgical and dental procedures. Thus, these patients should be treated prophylactically. A screening test should be done to evaluate the status of the diseased person. For this, blood pressure and the patient's pulse should be recorded. Dental treatment involving bleeding like extraction of teeth and apicoectomy are contraindicated if systolic blood pressure is higher than 180 mm of Hg and diastolic blood pressure is higher than 110 mm of Hg. However emergency pulp procedures can be carried out upto 200/120 blood pressure using non-adrenaline local anesthetic solution. Procedures involving hard dental tissue not involving pulp can be carried out safely upto 230/130 blood pressure, if patient is under physician's care. If blood pressure is higher than 230/130 than physician's advice should be taken. Uncontrolled diabetes is a contraindication of soft tissue surgery. Diabetes should be controlled before any soft tissue surgery. The following types of patients require special examination for systemic diseases.

- A. Patients presenting oral lesions due to production of foci of infection in any other part of the body.
- B. Patients presenting oral lesions due to reflex neurosis in other parts.
- C. Patients who manifest systemic disturbances of an inflammatory, infective or nervous type which may be productive of oral manifestations.
- D. Patients suffering from systemic complications which result in lowering of resistance power of the body.

### **Physiological Changes Associated with Aging**

These should be observed and studied and should not be confused with the pathological changes which are very important for a precise diagnosis and treatment planning.

- a. Physiological changes all over the body are as follows:
  - i. Loss of elasticity of skin and blood vessels
  - ii. Delayed healing
  - iii. More fragile bones
  - iv. Sensory impairment results in the following:
    - Hearing loss
    - Visual changes
    - Alteration in taste and smell
- b. Oro-dental changes occur due to aging and are as follows:
  - i. Attrition, abrasion and wear of proximal surfaces
  - ii. Gingival recession
  - iii. Extrinsic staining
  - iv. Edematous gingivae
  - v. Diminished salivary flow

### **Sociological and Physiological Conditions**

In these conditions, the social status of the patient is evaluated along with his attitudes, expectations, priorities, education, habits and parental history. Thus, by knowing the sociological and physiological conditions, the line of treatment can be adjusted accordingly. This helps us in executing the treatment plan as per expectations of the patient.

### **Risk or Susceptibility Assessment**

Every patient possesses a different set of risk or susceptibility factors for a particular disease. The persons who are at high risk for dental caries, should receive aggressive intervention to remove as many risk factors as possible. Thus, risk assessment should be used to guide the treatment plan.

There are various risk factors for caries which may be oral or non-oral. The oral factors are as follows:

1. Anatomy of tooth—Due to developmental deep pits and fissures, there is high risk of caries.
2. Composition of tooth—Lower the calcium and fluoride content, higher the risk for caries.
3. Habitat of oral flora—Higher the level of *Streptococcus mutans*, higher the risk for caries.
4. There is high risk of caries in persons with defective restorations.

5. Poor oral hygiene is also a major contributing factor for high caries risk.

The non-oral factors include the following:

1. Age—There is high risk for caries in younger persons below 18 years of age and in older person above 65 years of age.
2. Patients with reduced salivation are at high risk for caries.
3. Patients with very low or very high socio-economic conditions are at high risk for caries.
4. Diet—High intake of refined carbohydrate, and alcohol predispose the individual to high risk for caries. Low caries risk is found in individuals who take plenty of crude form of carbohydrates and proteins.
5. Genetic predisposition also accounts for high-caries risk.
6. Debilitated patients are also at a high risk for caries.
7. Lack of fluoride during tooth development accounts for high caries risk.

## EXAMINATION AND DIAGNOSIS

### Diagnostic Aids

Diagnostic aids are accessories to the clinical examination for correct diagnosis. Main diagnostic aids are the following:

- |                             |                                 |
|-----------------------------|---------------------------------|
| i. Visual examination       | viii. Gnathodynamometer         |
| ii. Radiograph              | ix. Laser Doppler flowmetry     |
| iii. Transillumination test | x. CT scan                      |
| iv. Vitality test           | xi. RVG                         |
| v. Anesthetic testing       | xii. Study models               |
| vi. Test cavity             | xiii. Laboratory investigations |
| vii. Bite test              | xiv. Dentinometer (Prepometer)  |

### Diagnosis

Diagnosis is a determination and judgement of variations from normal. The collection of facts from the health questionnaire, history and clinical and radiographic examination should be evaluated and analyzed to arrive at a diagnosis.

Clinical examination—It includes both extraoral and intraoral examination.

Intraoral examination—It includes the examination of soft and hard tissue.

### Visual Examination

It is the careful inspection and accurate investigation of conditions and data which are essential for treatment of a tooth. Cheek and lip retractors of various shapes help in proper examination of teeth. In examination, we observe both the normal and abnormal conditions. A thorough examination includes an ocular, i.e. visual and radiographic survey of the teeth and supporting structures, vitality tests of pulps and clinical and laboratory investigation of oral conditions along with the systemic manifestations.

## CLINICAL EXAMINATION

Clinical examination of the patient should be done thoroughly and in proper sequence. Common clinical examinations are as follows:

- a. Inspection
  - b. Palpation
  - c. Percussion
  - d. Auscultation
  - e. Exploration
- a. *Inspection:* When patient enters in the clinic, careful observation should be started about stature, gait, skin.
  - b. *Palpation:* After inspection, palpation is carried out by use of fingers. Any swelling on the face, lymph node, salivary gland mainly submandibular which needs bimanual palpation, one finger inside and other outside the mouth. Palpation also gives idea about the increase in temperature of the swelling or any part in region.
  - c. *Percussion:* Percussion gives information about the periodontal status of the tooth. Percussion is done with tapping, initially with low intensity by finger, then intensity is increased gradually by using handle of mouth mirror. Higher sensitivity to percussion in comparison to the adjacent teeth indicates the presence of periodontitis.
  - d. *Auscultation:* Auscultation is not of much importance, except rarely, e.g. auscultation to know about the clicking sound of the TMJ.



## 48 Textbook of Operative Dentistry

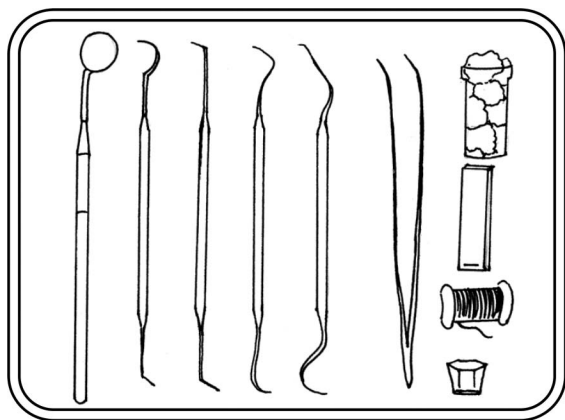
- e. **Exploration:** In this, clinical examination of the tooth is done by the use of explorer or probe. Periodontal probe is used to determine the level of epithelial attachment and periodontium.

Examination tray should include all instruments and materials required for examination of teeth (Fig. 5.1).

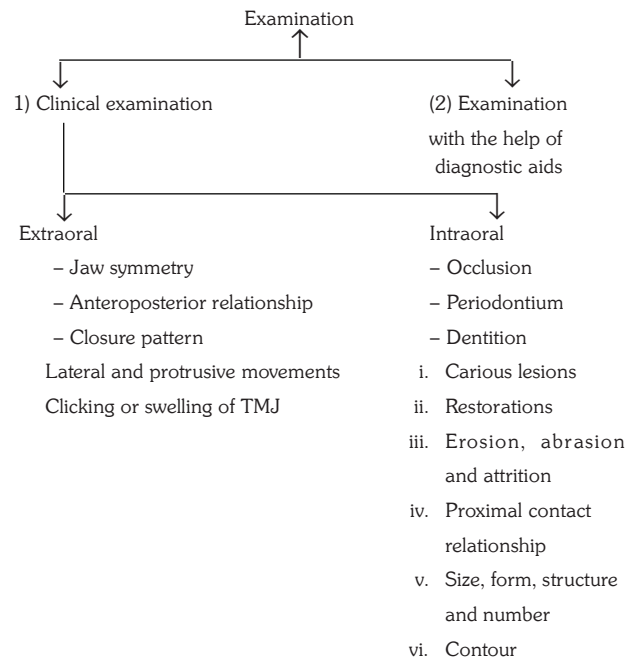
**Visual examination of dentition:** Visual examination of oral cavity is done in dry field with good light. Mouth mirror is used to reflect the light and retract tissues (Fig. 5.2).

Visual Examination includes the following:

1. **Contour:** The axial contours from occlusal to cervical on the crowns of teeth should be examined, as under-contoured crowns on the buccal/lingual surface require more attention for plaque removal and over-contoured crowns affect the periodontal health.
2. **Size, form, structure and number:** The importance of size relates primarily to whether the teeth can erupt normally into the space available, as placement of oversized restoration during mixed dentition may impede proper eruption, and undersized restorations may result in an undesirable shift in tooth alignment. The natural tooth form and contour are taken into consideration for restoration because natural tooth form and contour dictate the form and contour of the proposed restoration to a large extent. The number of teeth present is closely related to the age of the patient. Teeth may be absent congenitally

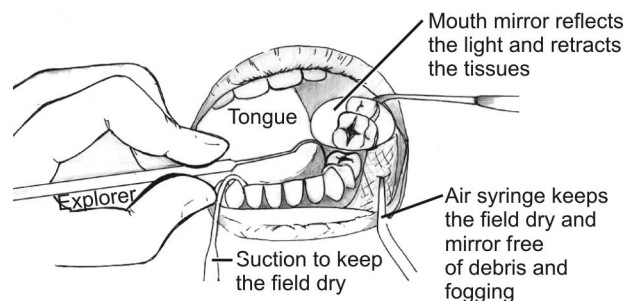


**Fig. 5.1:** Examination tray or Instrument tray for basic examination contains mouth mirror, probes of various shapes including periodontal probe, tweezer (cotton plier), cotton, articulating paper, dental floss and dappen dish



or may be missing as a result of dental caries and their subsequent extraction.

3. **Proximal contact relationship:** The examination of the proximal contact relationships includes both a visual inspection and a digital test with the help of a mirror and fine unwaxed dental floss respectively. These proximal contacts should prevent food impaction against the interdental tissues. So rough contact areas and proximal surfaces should be smoothed and open contacts that allow food impaction between the teeth should be restored. During the visual inspection, the contact area must be free of saliva. Overcontoured restorations should be recontoured and polished.



**Fig. 5.2:** Examination of mandibular teeth with explorer (probe)

4. **Color:** A deepening in color and increased opacity occur due to loss of enamel and thickening and sclerosis of the dentin as a result of normal physiologic changes. Tooth color and staining are of particular interest during the operative planning when a corrective esthetic restoration is required.
  5. **Erosion, abrasion and attrition:** Erosion is the loss of surface tooth structure mostly by chemical action. Erosion may be idiopathic. Abrasion occurs mostly by a wrong method of brushing. The defect is either an impressively sharp V-cut into tooth tissue or a shallow lesion. Abrasion is due to external means and attrition is due to internal means but both are due to the mechanical reduction of hard tooth tissue. Restoration may be required in such cases because of esthetics, sensitivity, nearness to the pulp or disturbance of the health of supporting tissues. The lesion is most sensitive in its initial stage, gradually it becomes less sensitive as secondary dentin is deposited. The resulting defect from erosion has rough surface and abrasion has smooth surface. The sharp edges resulting from attrition can result in tongue and cheek biting, so rounding of edge should be done.
  6. **Carious lesions:** Dental caries is diagnosed by the following.
    - a. Visual changes in tooth surface texture/color
    - b. Tactile sensation while using explorer
    - c. Radiography—Definite radiolucency indicating a break in the continuity of enamel is carious enamel.
    - d. Transillumination (used mostly for anterior teeth)
- Retractors**—Various types of retractors are used to retract the cheek and lips (Figs 5.3 and 5.4). A translucency producing a characteristic shadow on the proximal surface is adequate evidence of caries.
- Occlusal surface caries:** Caries is most prevalent in faulty pits and fissures of the occlusal surfaces. An occlusal surface is diagnosed as diseased if one of the following is present.
1. Chalkiness or softening of the tooth structure forming the fissure/pit.
  2. Brown-grey discoloration radiating peripherally from the fissure/pit.
  3. Radiolucency beneath the occlusal enamel surface.



Fig. 5.3: Cheek and lip retractor-Front view

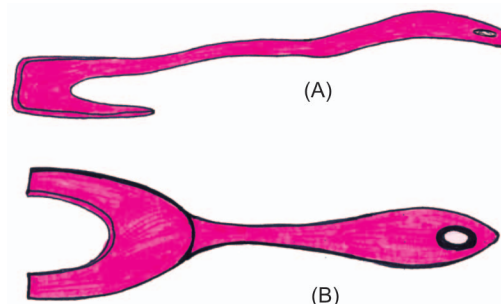


Fig. 5.4: Cheek retractor (A) side view (B) front view

**Precarious or carious pits:** These are occasionally present on cusp tips. Typically, these occur as a result of developmental enamel defects. Carious pits and fissures also occur on the occlusal two-third of the facial or lingual surface of the posterior teeth and on the lingual surface of maxillary incisors.

**Proximal surface caries:** It is a form of smooth surface caries. During this, the caries has invaded the proximal surface enamel and has demineralized the dentin. A white chalky appearance or a shadow under the marginal ridge may become evident.

Brown spots on intact, hard proximal surface of enamel, usually gingival to contact area are often seen in older patients. Such a spot is more resistant to caries due to fluorhydroxyapatite crystal formation. Thus in such cases, restorative treatment is not indicated.

## 50 Textbook of Operative Dentistry

**Root surface caries:** These carious lesions occur on the cemental surfaces of teeth. Active root caries is detected by the presence of softening and cavitation. It usually occurs in geriatric patients.

7. **Restorations:** On clinical evaluation of restorations the following conditions may be observed.
  - i. **Amalgam blues:** These are the discolored areas seen through the enamel in teeth. The bluish hue results either from the leaching of corrosion products of amalgam into dentinal tubules or from the color of underlying amalgam as seen through translucent enamel.
  - ii. **Proximal overhangs:** The tooth restoration junction is evaluated by moving the explorer back and forth across it. If the explorer stops at the junction and then moves onto the restoration, an overhang is present. This should be corrected, otherwise it will result in the inflammation of the adjacent soft tissues.
  - iii. **Marginal gap or ditching:** It is the deterioration of the restoration-tooth interface on occlusal surfaces as a result of wear or fracture. Shallow ditching, less than 0.5 mm deep usually requires patchwork repair. If ditch is too deep, restoration should be completely replaced.
  - iv. **Voids:** These also occur at the margins of amalgam restorations. If the void is at least 0.3 mm deep and is located in the gingival one-third of the tooth crown, then the restoration should be replaced.
  - v. **Fracture line:** A fracture line that occurs in the isthmus region generally indicates fractured restoration and thus defective restoration needs replacement.
  - vi. The marginal ridge portion of the amalgam restoration should be compatible with the adjacent marginal ridge.
  - vii. Recurrent caries at the margin of the restoration if detected is an indication for repair or replacement.

### Transillumination

Transillumination is helpful to see the fracture in the traumatized tooth. In a dark room a sharp pointed light is placed lingual to the tooth inside the mouth and labial surface is examined by a single eye, keeping the other eye closed, through a thin roll of black paper.

### Vitality Tests

Vitality test of all the traumatized and deeply carious teeth should be done.

### Electric Pulp Test

Electric/battery pulp tester is a device used to determine the status of vitality of the pulp. If pulp does not respond to excessive current then pulp is degenerated. If it requires less current than the normal to give a response, it means pulpal hyperemia, pulpitis or pulp inflammation is present. Electric pulp testing is not always reliable. Tip of the tester should not touch the gingiva or the metallic restoration like amalgam filling or metal crown to avoid wrong reading (Fig. 5.5).

### Thermal Testing

Thermal testing includes both heat and cold application. It is used to test pulpal inflammation.

A. **Heat testing:** Heat testing is performed by using the following:

- a. hot water
- b. hot gutta percha
- c. hot impression compound
- d. hot burnisher or any other blunt metal instrument.

By any means if response occurs, then heat should be removed immediately to avoid discomfort and damage to pulp. Rubber dam should be applied if hot water is used.

B. **Cold testing:** Cold testing is done by using the following:

- i. Cold air
- ii. Cotton pellet saturated with ethyl chloride
- iii. Pointed ice pencil application
- iv. Carbon dioxide snow.

One of these is applied directly on the tooth surface. Rubber dam is applied before using cold.

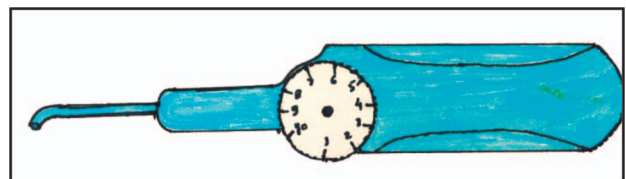


Fig. 5.5: Battery operated pulp tester

### Anesthetic Testing

This test is used when patient complains of pain over the whole side of the jaws and no pathological change is evident, or when the usual tests have failed to find the affected tooth. Inferior alveolar nerve block is given. If pain disappears then the problem is in the mandibular teeth, otherwise the etiology may be in the maxillary teeth. In the mandibular teeth, local anesthesia is administered posterior to suspected teeth and in maxillary teeth LA is given anterior to the suspected area. In this way by the method of elimination etiological tooth is identified.

### Test Cavity

A cavity is made upto DE junction with slow speed and without water coolant. When bur reaches dentino-enamel junction, thermo-sensitivity or pain is felt by the patient and it indicates pulp vitality. In this case a sedative cement is applied on the pulpal floor and cavity is filled by the restorative material.

### Bite Test

On releasing biting force sharp pain is felt in vertically fractured tooth. It is because when pressure is released pulp chamber gets shortened. Now no more space is available for the increased inflammatory pressure on the nerve endings and pain is produced. Food coloring dye can also be placed on the occlusal surface for finding out fracture line on the crowns of the teeth.

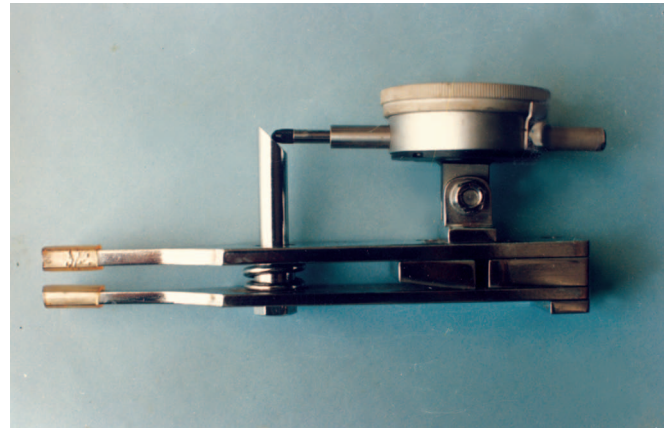
### Gnathodynamometer

Gnathodynamometer is used to evaluate the intensity of pain in tooth due to inflammation of periapical tissues. It gives reading in numericals which can be divided into various types. According to Gnathodynamometer readings the types of pain are: (a) very mild, (b) mild, (c) moderate, (d) severe.

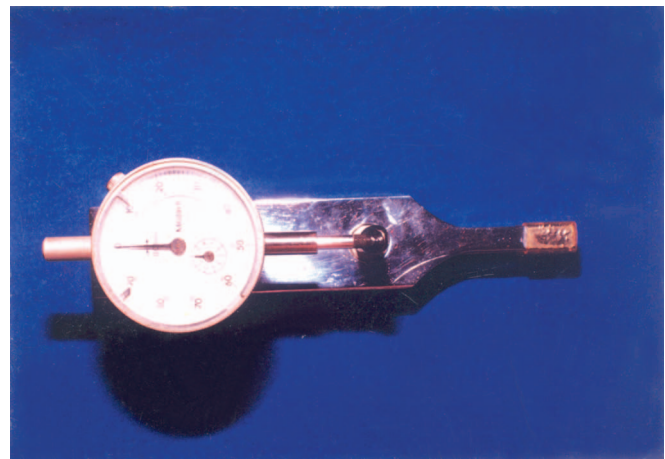
Biting force is recorded on healthy normal teeth of opposite arch and on periapically involved teeth and also after treatment. A mean is obtained separately of each biting measurement which is compared to pressure of the normal healthy contralateral teeth (Figs 5.6 to 5.8).

### Laser Doppler Flowmetry

It is a recent diagnostic aid in which laser beam is applied on occlusal aspect of pulp. Reflected rays scattered by



**Fig. 5.6:** Side view of the Gnathodynamometer



**Fig. 5.7:** Top view of the Gnathodynamometer

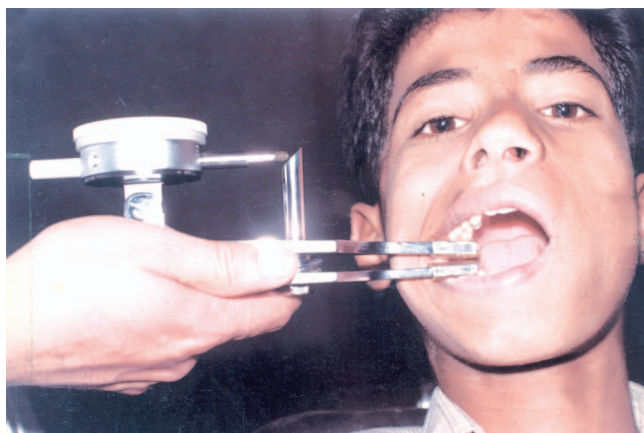
the blood cells undergo a Doppler frequency shift. This is processed to yield a signal. The reliability of test is 97% which is higher than any other method of pulp vitality testing.

### CT SCAN (Computed Tomography Scan)

CT scan is an imaging method in which a cross-section of structure in the body plane is reconstructed by a computer program from the X-rays absorption of the body in the image plane.

CT scan provides a three-dimensional picture so we can find the exact size and location of the pathology. It can give exact location of intruded tooth inside the alveolus in trauma cases. CT scan also gives image of structure like blood vessels, nerve or any other organ.





**Fig. 5.8:** Gnathodynamometer in use

### **RVG (Radiovisiography)**

RVG is a device used to develop radiographic image of an object on a video monitor. In this radiation exposure is reduced by eighty percent. Intraoral sensor translates the image into an electric signal transmitted to the display processing unit which magnifies it four times for immediate display on the monitor. The image is digitized and memorized by the computer and is displayed B/W or colored by the display monitor. It also produces multiple images simultaneously (see Fig. 1.1).

### **Advantages of RVG**

1. Radiation exposure is reduced.
2. Image can be permanently recorded with time and date.
3. Image can be enlarged to study the minute details and for the comparison.
4. Radiographic film, dark room, developer and fixer, etc. are not required.
5. Instantaneous image is displayed.
6. Simultaneously all the procedures can be seen while being performed.
7. Time is saved. No time is required for developing and fixing the film.

### **Study Casts**

Study casts are essential to develop the proper treatment plan. They help in study of the following:

- a. To visualize existing conditions and to educate the patient

- b. The occlusal relationship
- c. Functional occlusion and occlusion abnormalities
- d. Tilted or extruded teeth
- e. Cross bite
- f. Plunger cusps and wear facet.

### **Laboratory Investigations**

Most common investigations required are TLC, DLC, BT, CT, etc. some laboratories offer package deal for all important tests called 'Preop profile' which includes HIV test also.

### **Occlusion Examination**

Through it, we can identify the signs of occlusal trauma such as enamel cracks, tooth mobility and notation of occlusal abnormalities. In this, supra-erupted teeth, spacing, fractured teeth and marginal ridge discrepancies should be noted. Teeth are examined for abnormal wear patterns, such as nocturnal bruxism or para-functional habits in addition to unfavorable occlusal relationships such as plunger cusp, which may result in food impaction. The occlusal examination should be considered for restorative treatment plan.

### **Periodontium Examination**

It shows change in color, form, density, level of attachment and bleeding tendency. The depth of gingival sulcus is determined by systemic probing using a periodontal probe. A sulcus depth greater than 3 mm and the sites that bleed upon probing should be recorded in the patient's chart. The presence of pocket may also indicate periodontal disease. Gingival recession and the teeth mobility (class 1 to 10) should be evaluated.

The presence of plaque should also be considered in the periodontium examination and the restorations should be contoured accurately to maintain proper periodontal health.

### **New Mobility Index (NMI)**

This index has been designed by the authors of this book, considering the all round advancements in various fields, i.e. treatment techniques, equipment, and medicaments, etc. The mobile teeth which were previously considered having hopeless prognosis are



**Table 5.1:** Severity of mobility of teeth and their prognosis

| Severity Scores | Faciolingual mobility in mm      | Mesiodistal mobility in mm | Alveolo-occlusal (Vertical) mobility in mm | Percentage of chances of success with modern treatment                   |
|-----------------|----------------------------------|----------------------------|--------------------------------------------|--------------------------------------------------------------------------|
| 1.              | Physiological mobility up to 0.5 | 0                          | 0                                          | 100, Generally no treatment is required except prophylaxis and home care |
| 2.              | 0.5 to 1                         | 0                          | 0                                          | 100                                                                      |
| 3.              | 1 to 1.5                         | 0                          | 0                                          | 95                                                                       |
| 4.              | 1.5 to 2                         | 0                          | 0                                          | 90                                                                       |
| 5.              | 2 to 2.4                         | less than 0.5              | 0                                          | 80                                                                       |
| 6.              | 2.5 to 3                         | 0.5 to 1                   | 0                                          | 70                                                                       |
| 7.              | 3 to 3.5                         | 1 to 1.5                   | less than 0.5                              | 60                                                                       |
| 8.              | 3.5 to 4                         | 1.5 to 2                   | 0.5 to 1                                   | 40                                                                       |
| 9.              | 4 to 4.5                         | 2 to 2.5                   | 1 to 1.5                                   | 20                                                                       |
| 10.             | More than 4.5                    | More than 2.5              | More than 1.5                              | 00                                                                       |

now successfully treated to provide useful service for decades. Therefore, a new classification of mobility has been described covering greater degrees of mobility in all the three dimensions alongwith probable prognosis (Table 5.1). Prognosis of teeth having mobility in various directions.

### Vitality

Tooth vitality can be checked by various vitality tests which can produce mechanical, thermal or electrical stimuli. The mechanical stimulation includes probing or blowing air onto exposed dentin, test cavity preparation and percussion.

Thermal pulp testing involves either heating or cooling the tooth.

Electric pulp testing relies on direct electrical stimulation of sensory nerves in the pulp.

### Radiographic Examination

For patients with oral disease, radiographs are required to verify the existence of the disease and to define its extent prior to treatment.

Radiograph gives information about dental caries, exposure of the pulp, number of roots, shape and length of root canals, presence of pulp stone, resorption of bone, type of bone resorption, internal and external root resorption, thickening of periodontal ligament and periapical pathology, etc.

### Types of Radiographic Films and Various Views

- | Intraoral films                      | Extraoral films               |
|--------------------------------------|-------------------------------|
| a. Intraoral Periapical (IOPA) X-ray | a. Lateral oblique view       |
| b. Bite wing X-ray                   | b. Lateral cephalometric      |
| c. Occlusal X-ray                    | c. PA (Postero-anterior) view |
|                                      | d. Water's view               |
|                                      | e. Submentovertex             |
|                                      | f. Reverse Towne's view       |
|                                      | g. Transpharyngeal view       |
|                                      | h. Panoramic view             |

#### Intraoral Periapical X-rays (IOPA Films)

These radiographs can show the pathologic conditions in relation to the supporting bone, the periodontal membrane, the roots and the crowns of the teeth.

These are available in three sizes:

- Size 0 (For children)—22 mm × 35 mm
- Size 1 (For adult-anterior teeth)—24 mm × 40 mm
- Size 2 (Standard size)—31 mm × 41 mm

Intraoral periapical X-rays are used to see the periapical pathology, contour of the interdental bone, number of roots and root morphology.

#### Bite Wing Radiographs

Bite wing radiographs are taken to see mainly the proximal caries and also the caries in the crown portion. Various sizes of bite wing X-ray films are as follows.

## 54 Textbook of Operative Dentistry

1. Size 0 (For children)—22 mm × 35 mm
2. Size 1 For adult (anterior teeth)—24 mm × 40 mm
3. Size 2 For adult (posterior teeth)—31 mm × 41 mm
4. Size 3 (For all posterior teeth of one side in one film)—27 mm × 54 mm

**Occlusal film:** Most common size of occlusal X-ray film is 57 mm × 76 mm. It is used to take the occlusal view X-ray of the entire arch in one film. It provides information about the size of the lesion and also whether the lesion is present lingually or facially.

### Panoramic Radiographs (Panoramic View)

It is also called “bird’s eye view” or ‘orthopantograph’ (OPG). This view is used to examine both upper and lower teeth and jaws in a single radiograph. This view is very helpful to find out unerupted supernumerary teeth and eruption sequence of teeth. It is also used to evaluate the growth and development of jaws and to detect disease of the temporomandibular joint.

This type of radiograph produces a fine view of the teeth and associated structures including temporomandibular joints. It also accounts for the relative positions of the teeth in a complete survey.

Therefore, these radiographs are an important and valuable diagnostic aid.

### Measuring Suprapulpal Dentin

A. **Dentinometer:** This is a specially designed device in which the electric current passes through dentinal fluid present in the dentinal tubules. The resistance measurements provide clinically relevant information on the localization of the pulp horn tips and the thickness of the residual dentin layer above the pulp chamber from the fact that the dentinal fluid in the dentinal tubuli conducts the electrical current in the dentin. This hypothesis proves that the electrical resistance is dependent on the dentin thickness above the pulp.

The electrical resistance value determines the thickness of dentin.

B. **Prepometer:** It is a pen like instrument for safe preparation above the living pulp. It helps in measuring thickness of dentin above the living pulp during preparation. Measurements of dentin thickness can be easily read by different colors of beaming electrodes. Green color shows safe more

cutting, yellow color shows only essential cutting with caution and red color shows no more cutting. It helps in safe preparation, specially in young teeth with large pulp or elongated tilted teeth where chances of pulpal exposure are more (see Fig. 1.2).

## TREATMENT PLANNING

A treatment plan is a sequential series aimed to control etiological factors, repair existing damage and create a functional, maintainable environment. The rate of prognosis of a particular disease is based on the successful treatment plan.

Outlines for treatment planning

- I. Systemic treatment
  - a. Referral to a physician for systemic evaluation and treatment as indicated by history and clinical findings.
  - b. Appraisal of the influence of systemic treatment on the dental treatment plan.
  - c. Premedication with antibiotics or sedatives as indicated by the history.
  - d. Corrective therapy for oral infection.
- II. Preparatory treatment
  - a. Oral surgery
  - b. Endodontic treatment
  - c. Caries control
  - d. Periodontal treatment
  - e. Orthodontic treatment
  - f. Occlusal adjustment
- III. Corrective treatment
  - a. Operative dentistry
  - b. Prosthetic dentistry
- IV. Periodic recall examinations and maintenance treatment: Successful treatment requires proper sequencing. A proper co-ordination is essential between the patient and clinician for an effective treatment plan. Treatment plans are affected by patient’s preferences, health, emotional status and the financial status. Thus, a treatment plan is a multiphase and dynamic series of events. A complex treatment plan should be sequenced in the following phases.
  - a. A control phase
  - b. Caries prevention phase
  - c. A holding phase
  - d. A definitive phase
  - e. A maintenance phase

Patient's \_\_\_\_\_ First \_\_\_\_\_ Mid.Init. \_\_\_\_\_ Address \_\_\_\_\_ Phone No. \_\_\_\_\_  
 Reg. No. \_\_\_\_\_ Date \_\_\_\_\_  
 Last name \_\_\_\_\_

### Questions to be answered by the patient in his/her own words.

For the diagnosis of dental pain, the following questions should be asked from the patient and deduced by the interview and clinical and radiographic examinations:

### Questions to be Answered by the Patient

- Can you point to the tooth or area which pains?  
 Upper right      Upper left      Upper front  
 Lower right      Lower left      Lower front
- When did you first feel the pain or discomfort?
- Tick mark any of the following that describes(s) the character of your pain.  
 Pulsating    Dull      Sudden      Constant  
 Nagging      Sharp      Off and on
- Is the pain spontaneous?      Yes      No
- Is the pain is so severe that it wakes you up at night?      Yes      No
- The pain increases or decreases by which of the following? (+ mark for increase and – mark for decrease. The no. of + or – marks will show the intensity of increase or decrease).  
 Heat  
 Cold  
 Sweets  
 Chewing /biting  
 Air  
 Other
- Once started usually how long does the pain last?  
 Minutes/hours \_\_\_\_\_
- What relieves the pain?      Cold/hot/pressure\_\_\_\_\_

### Clinical Examination

- |                                                      |        |    |                             |
|------------------------------------------------------|--------|----|-----------------------------|
| 1. Caries                                            | Yes    | No |                             |
| 2. Extensive restorations                            | Yes    | No |                             |
| 3. Sensitive to percussion                           | Yes    | No |                             |
| 4. Sensitive to palpation                            | Yes    | No |                             |
| 5. Response to cold test                             | Normal | No | Pain<br>response<br>lingers |
| 6. Response to heat test                             | Normal | No | Pain<br>response<br>lingers |
| 7. Periodontal pocket depths in mm.                  |        |    |                             |
|                                                      | ML     | L  | DL MF F DF                  |
| 8. Degree of Mobility 1,2,3,4,5,6,7,8,9,10           |        |    |                             |
| 10. Wear facets or signs of occlusal trauma          | Yes    | No |                             |
| 11. Craze lines emanating from developmental fissure | No     |    | Yes                         |
| 12. Exposed root surface                             | Yes    | No |                             |
| 13. Presence of sinus tract                          | Yes    | No |                             |
| 14. Tooth discoloration                              | Yes    | No |                             |
| 15. Other if any, specify                            | Yes    | No |                             |

### Radiographic Examination

- |                                              |     |    |
|----------------------------------------------|-----|----|
| 1. Depth of cavity, caries Type A/B/C/D      | Yes | No |
| 2. Extensive restoration class of cavity     | Yes | No |
| 3. Periapical pathology                      |     |    |
| Widened periodontal ligament                 | Yes | No |
| Radiolucent lesion                           | Yes | No |
| 4. Root fracture                             | Yes | No |
| 5. Bone Levels                               |     |    |
| Furcation                                    |     |    |
| Interproximally                              |     |    |
| NB Mobility as per New Mobility Index (NBI)– |     |    |

**Fig. 5.9: A typical history and record sheet**

## 56 Textbook of Operative Dentistry

Patient's \_\_\_\_\_ First \_\_\_\_\_ Mid.Init. \_\_\_\_\_ Address \_\_\_\_\_ Phone \_\_\_\_\_  
No. \_\_\_\_\_

Reg. No. \_\_\_\_\_ Date \_\_\_\_\_

Last name \_\_\_\_\_

| Universal<br>system of<br>tooth No. | Oral findings<br>surfaces |   |   |   |   | Radiographic findings<br>surfaces |   |   |   |   | Treatment plan<br>(tooth No. surfaces<br>& materials) |   |   |   |   | Comments<br>and<br>conclusions | Sign |
|-------------------------------------|---------------------------|---|---|---|---|-----------------------------------|---|---|---|---|-------------------------------------------------------|---|---|---|---|--------------------------------|------|
|                                     | O/I                       | D | M | B | L | O/I                               | D | M | B | L | O/I                                                   | D | M | B | L |                                |      |
| 1.                                  |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 2.                                  |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 3.                                  |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 4.                                  |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 5.                                  |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 6.                                  |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 7.                                  |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 8.                                  |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 9.                                  |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 10.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 11.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 12.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 13.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 14.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 15.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 16.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 17.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 18.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 19.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 20.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 21.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 22.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 23.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 24.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 25.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 26.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 27.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 28.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 29.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 30.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 31.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |
| 32.                                 |                           |   |   |   |   |                                   |   |   |   |   |                                                       |   |   |   |   |                                |      |

Surfaces O/I = Occlusal/Incisal, D=Distal, M=Mesial, B = Buccal, L= Lingual

**Fig. 5.10:** Record of Treatment Plan. A code color should be used to identify the material and type of the restoration

## Treatment and Payment Record

Patient Name \_\_\_\_\_ **Registration No** \_\_\_\_\_

[illegible]

**Fig. 5.11:** A typical record sheet of treatment rendered and payment status



## 58 Textbook of Operative Dentistry

### Control Phase

The main objective of this phase is to eliminate the etiological factors for stabilization of patient's dental health. The control phase is aimed at elimination of the following:

1. Pain
2. Conditions preventing maintenance
3. Active disease such as caries and inflammation
4. Latent causes of disease.

### Caries Prevention Phase

The followings methods are used for caries prevention and control.

- a. Chemical
  - Topical fluoride stimulate remineralization
  - Antimicrobial agents alter the oral flora.
- b. Surgical
  - Diseased tooth portion is removed and restored with proper restorative material
- c. Behavioral
  - Change of dietary habits and improved oral hygiene.
- d. Mechanical
  - Enameloplasty, sealants, restoration of defective contours
- e. Dietary
  - Alteration of diet character
- f. Other
  - Stimulation of salivary flow

### Holding Phase

It comes after the control phase and before the definitive phase. Thus, holding phase is a time between control phase and definitive phase that allows time for healing and analysis of inflammation. During this phase, patient is advised home care habits and motivated for further treatment. The initial treatment is re-evaluated before the definitive treatment.

### Definitive Phase

This phase comes after holding phase and is based on

the need of further care in a patient after the re-assessment of initial treatment. It involves some forms of endodontic, orthodontic, periodontic, oral surgical and operative procedures prior to fixed or removable prosthodontic treatment.

### Maintenance Phase

Regular recall examination should be included in this phase. Recall visits can vary from patient-to-patient. Patients who are at high risk for dental caries should be examined more frequently, as in 3 to 4 months. Recall visits for the patients at low risk for dental caries may range from 9 to 12 months.

### Treatment Record

All the activities from the initial treatment plan to the final treatment plan should be maintained in a form of record. This record can also become a legal document in support of a particular action a dentist may take while rendering a treatment. This record must be dated, with the headings made chronologically.

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# 6

## *Primary Considerations for Operative Procedures*

There are some general conditions which are important for all operative procedures. Among them the most important ones have been discussed in this chapter.

### **POSITION OF PATIENT AND OPERATOR**

The patient who is in a comfortable position is more relaxed, has less muscular tension and is more capable of cooperating with the operator. The comfortable position of operator causes less physical strain and fatigue and reduces the chances of developing musculo-skeletal disorders. An efficient patient and operator position is necessary for the welfare of both persons. Positions that create unnecessary curvature of the spinal column or slumping of the shoulders should be avoided. Proper positioning of the operator and the patient may help in access and visibility to the operating field, and patient safety.

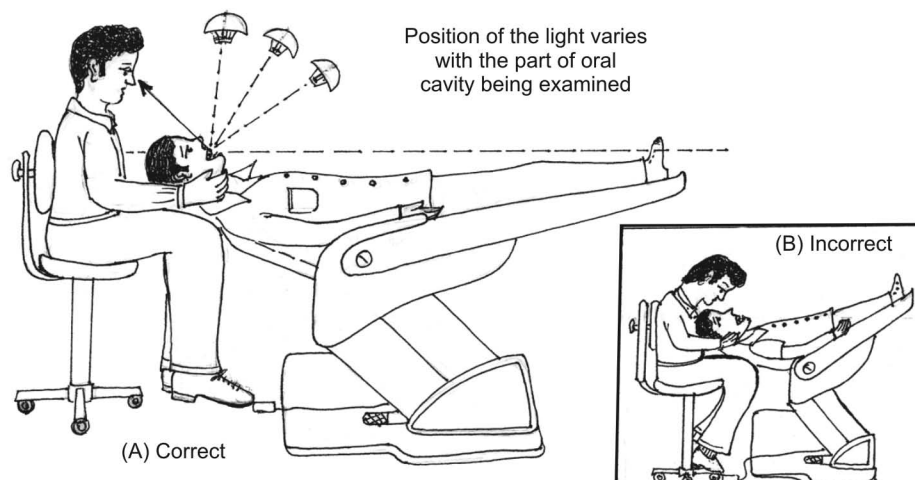
A desirable position for the operator is one in which the operator is seated with his back resting on back rest of the stool and with his feet flat on the floor, legs relaxed and relatively together and thighs parallel to

the floor. Proper balance and weight distribution on both feet is necessary when operating from a standing position. Correct and incorrect postural positions of the operator and the patient have been shown in Figures 6.1A and B.

### **PATIENT AND CHAIR POSITIONS**

The most common patient positions for conservative dentistry are almost supine or reclined at 45 degrees. Both positions are recommended for sit-down dentistry and uses of both positions depend on the dental arch being operated.

In a supine position, the patient's ankles and chin should be at the same level. (If the patient's legs are positioned higher than the head for long periods, postural hypotension may occur). The supine position enables the operator's forearm to be parallel to the floor when working in the operative field. After the patient is seated on the chair, the headrest or neck rest cushion is positioned to support the head and to elevate the chin slightly from the chest. In this position, neck muscle strain is minimal and swallowing is facilitated. The chair



**Fig. 6.1:** (A) Correct and (B) Incorrect postural positions of the operator and patient

## 60 Textbook of Operative Dentistry

is then adjusted to place the patient in a reclining position. Chair design and adjustment permit maximal operator access to the working area. To improve infection control, chairs with a foot switch for patient positioning are recommended.

### Positions for Operator

For the right-handed operator, there are five positions : right front, right and right rear or the 7, 8, 9, 10 and 11 o'clock positions respectively. For the left-handed operator, there are five positions on left front, left and left rear or and referred to 1, 2, 3, 4, 5 o'clock positions respectively. Direct rear or front positions 12 or 6 o'clock position is used for certain areas of mouth by both left and right handed operators. All of the positions may be used from the standing or seated operating position (Fig. 6.2).

### Front Positions

The front position facilitates oral examination and work on mandibular anterior teeth, mandibular posterior teeth and maxillary anterior teeth.

### Right or Left Position

This position facilitates work on the facial surfaces of the mandibular teeth, maxillary right or left posterior teeth and the occlusal surfaces of the mandibular right or left posterior teeth. In this condition, position of the operator is directly to the right or left of the patient.

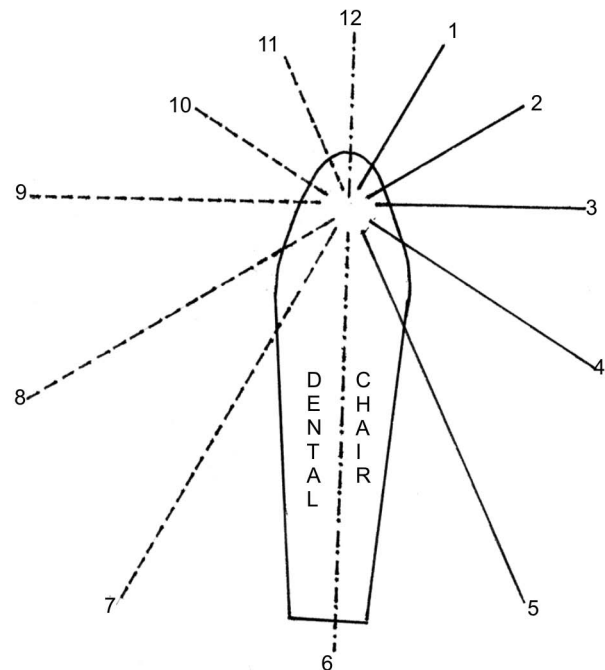
Right or left rear position is the position of choice for most operating procedures. The position of operator is behind and slightly to the right or left of the patient. The left or right arm is positioned around the patient's head. However, the position of the arm may change with change in the design of the dental equipment.

### Direct Rear Position

This position is primarily used for operating on the lingual surfaces of mandibular anterior teeth. The operator is sitting behind the patient, looks down over the patient's head. This position has limited application.

## GENERAL CONSIDERATIONS

The operator may rotate the patient's head from side to side or from backward or forward, to facilitate visibility and accessibility of the operating field for



**Fig. 6.2:** Various Operating Positions: These can be used for standing and seated positions. Positions shown with broken lines 7 to 11 o'clock are for right handed operator. Positions shown with continuous lines 1 to 5 o'clock are for left hand operator. Positions of 6 (direct front) and 12 o'clock (direct rear) shown by dot and dash can be used by both right and left handed operators

convenience when operating in the mandibular arch. The mandibular occlusal surfaces should be oriented approximately 45 degree with the floor. When operating on the maxillary arch, the maxillary occlusal surfaces should be oriented approximately perpendicular with the floor.

### Operating Stools

The face of the operator should not come in close proximity to that of the patient. However, procedures done in small, inaccessible sites may require close proximity to the face of the patient for adequate access and visibility. Another important aspect of proper operating position is to minimize body contact with the patient. Unnecessary contact is unpleasant and must be avoided. When operating the procedure for an extended period of time, the operator will find a certain amount of rest and muscle relaxation from changing

operating positions. Changing the operating positions reduces muscle strain and lessens fatigue, especially when operating from a standing position. Sitting position is more relaxing and requires less expenditure of energy. Proper distribution of load on both feet is essential when operating from a standing position.

There are a variety of operating stools available for the dental surgeon and the assistant. The design of the stool is important. It should be sturdy and well balanced to prevent tipping or gliding away from the dental chair. The seat should be well padded with smooth cushion edges and should be adjustable up and down. The backrest should be adjustable up and down as well as forward and backward. Operator's stools do not have a foot rest. The upper body of the operator should be positioned so that the spinal column is straight or bent slightly forward. The thighs should be parallel to the floor and feet should be flat on the floor.

The seated position of the dental assistant is very slightly higher than the operator and the stool height is 10 to 15 cm higher than the operator's stool for maximum visibility and access. The stool of the dental assistant should have an adequate footrest and lockable castors so that a parallel thigh position can be maintained with good foot support.

When properly seated, the operator and assistant are capable of providing continuous dental service for about 8 hours with one hour lunch break and two tea or coffee breaks of ten minutes each.

### **Exchange of Instruments**

The transfer zone is located below the patient's chin and several centimeters above the patient's chest (which is covered by the napkin), where all instruments and materials are transferred (exchanged) between the operator and the dental assistant. During proper exchange of instruments, it should not be necessary for the operator to remove his or her eyes from the operating field. To maximize operating efficiency, whether treating one tooth or several, each instrument should be used completely on all the teeth before proceeding to the next instrument. This will also minimize the number of instrument exchange and wastage of time and will result in reduced chairside time and increased output.

The success of clinical conservative dentistry is very much dependent upon the visibility of the operating

field. The operator must be able to see clearly the details of each procedure. Normal accommodation of the operator's eyes is necessary to maintain a proper working distance. After the age of 40 years, operator may require magnification devices such as bifocal eyeglasses, loupes and surgical telescopes to compensate the loss of normal accommodation of eye and also to protect eye from injury.

### **LIGHTING OF THE OPERATING FIELD**

The operatory light should be positioned at an arm's length from the operator. A light closer than this to the operating field does not increase the light intensity and visibility. It may increase patient discomfort from production of heat and hindrance to the operator by physically impairing movement of hands near the operating field. Lower positions of light are used for the maxillary arch and when using indirect vision and reflecting the light. Higher positions of light are used for the mandibular arch when using direct vision (Fig. 6.1A).

### **INSTRUMENT TRAY**

The basic instrument tray set up required for intraoral procedures essentially includes an explorer, mouth mirror, and cotton tweezer. According to need, other instruments, dappen dish and disposable cotton products like pellet and rolls etc. are added in the instrument tray (see Fig. 5.1)

An explorer (probe) is a sharp pointed instrument of various shapes for digital examination of tooth and restorative surfaces with their margins. A number of explorer designs are used by dental practitioners. Certain explorer designs are designed for specific use, such as for diagnosis of proximal caries.

For selection of an explorer, three factors may be considered - (1) The design of the tine (sharp tip), shank and handle (2) Resilience and stiffness of the tine (3) Sharpness of the point itself.

*Explorer or probe:* Explorer design permits an approach to the area being examined. Obviously, some designs of explorers permit greater convenience for the operator. A periodontal probe is also used for the intraoral examination, especially for examination of pockets. A periodontal probe is part of the basic

## 62 Textbook of Operative Dentistry

instrument tray set up and its working tip is blunt. Its tine has scale marks to measure the depth of the periodontal pocket.

*Mouth mirror:* The mouth mirror is often used for reflecting the light and viewing the operating site by retracting the cheek, lip and tongue. It is of two types plane and magnifying. Mouth mirrors are available in a variety of sizes and reflecting types. The No. 2 (1.8 cm diameter) and No. 4 (2.5 cm diameter) sizes of mouth mirrors are commonly used for intraoral procedures. The No. 2 mouth mirror is more useful in children. It provides greater freedom for suitable work of instrument. Mouth mirror is particularly valuable in the posterior region of dental arch. Selection of a mouth mirror is subject to personal preference; the plain front surface types of mouth mirrors are commonly used because they minimize visual distortions.

*Cotton tweezers:* Cotton tweezers should have angled tips for convenience in carrying materials into the mouth

and retrieving them. Fine serrations on the facing sides of tips help in the secure holding of materials. The tips of the tweezer should be able to firmly hold the fine tip of the hair of the hand. Cotton wool pellets, small gauze pieces, dental floss or tape and articulating papers are part of the basic examination tray.

A cotton wool and gauze are used for drying the operating area and help in retracting and examination of soft tissues. Dental floss or tape can be used to assess proximal contacts or proximal caries. Articulating papers are required for assessing occlusal contacts.

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# 7

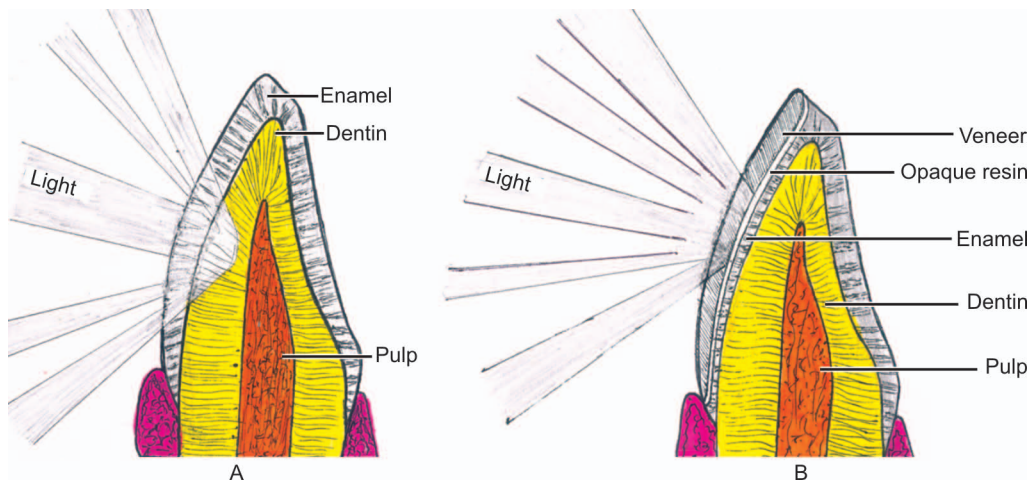
## Color and Shade Matching

Operative dentistry is an art and science which restores the tooth to its functional form, esthetics and health. Esthetics requires the artistic skill of balancing illusion with reality. There are various factors alongwith the clinician's skill and experience which are required to maintain the integrity and esthetics of a tooth to be restored. Shades of color vary in different light conditions. The nature of the substance of enamel and dentin and the color of gingiva influence the ultimate color of the teeth. In esthetic dentistry focus is on merging function and beauty with the values and the individual needs of the patient. Color and shade are among the major factors in achieving esthetics in restorations. All dental surgeons must be well trained and experienced in shade matching. Shade and color are something that make an object more attractive and appealing, therefore, they should be learned as a separate entity.

### FUNDAMENTALS

Fundamentals of color and shade matching are as follows.

1. *Source of light:* Light is a form of radiant energy consisting of electromagnetic waves, which is a combination of different wavelengths measured in nanometer (nm).  
380 to 760 nm- visible light  
less than 380 nm- ultraviolet light, X-rays and gamma rays  
more than 760 nm- Infrared range.
2. *Optical characteristics:* When light is being pointed to an object it is either reflected, transmitted or absorbed.
  - A. *Reflection:* Reflected light rays bounce back from the object to which it hits. If all the light is reflected, the object appears white.  
Reflection is of the following two types:
    - i. *Regular or specular reflection*—Light is reflected in a single direction, seen on perfectly smooth surfaces.
    - ii. *Diffused reflection*—Light is reflected in various directions, seen on rough surfaces; these reflections carry information about the color of object.
  - B. *Transmission:* When light emerges through an object, the process is called as transmission.
  - C. *Refraction:* When light rays travel from one medium into another medium, the velocity changes and light ray is bent. The bending of light is called refraction.
  - D. *Deflection:* Deflection is the reflection of light from a surface in a direction different from that of entry.
  - E. *Absorption:* Absorption is the phenomenon in which light is absorbed fully or partially by an object. Fluorescence is the capacity of the object to emit light waves after absorption of light. The natural teeth possess this inherent fluorescence property while artificial (man made) teeth do not have this property.
  - F. *Transparency:* It is the property of the medium which allows total transmission of light through the object without any distortion, e.g. clear glass.
  - G. *Translucency:* When transmission of light is partial and is in a diffused manner through a medium, so that clear and definite image cannot be seen, then medium is said to be translucent, e.g. frosted glass and the property is called translucency (Fig. 7.1).
  - H. *Opacity:* When no light is transmitted through a medium then the medium is said to be opaque. Opaque material absorbs all the light. In dentistry translucency and opacity of restoration are of importance.
  - I. *Scattering of light:* It is the random deflection of light rays by fine particles. In a heterogeneous medium, the number of reflections and refractions occurring inside the media is considerably increased because of various media of different



**Fig. 7.1:** Translucency and light penetration-faciolingual sections (A). In normal healthy teeth light normally penetrates deeply through enamel and dentin before it is reflected outward. This produces life-like esthetic vitality. (B). In restored teeth there is limited light penetration by opaque resin media under the veneers, hence there is limited esthetic vitality

densities in the path of light. This phenomenon is called as scattering of light. Amount of light scattered depends upon the difference in the refractive index of dispersed and dispersion medium as well as particle sizes of the dispersed phase.

- J. *Surface gloss*: Surface gloss determines the type of reflection occurring on a surface. On glazed surface, specular reflection predominates, whereas on rough surface diffuse reflection predominates.

## Color

Color is the property of a medium due to absorption of certain light rays and reflection of others within the range of visible light wavelengths (380 to 760 nm). Object seems to be of that color which is reflected back and all others are absorbed.

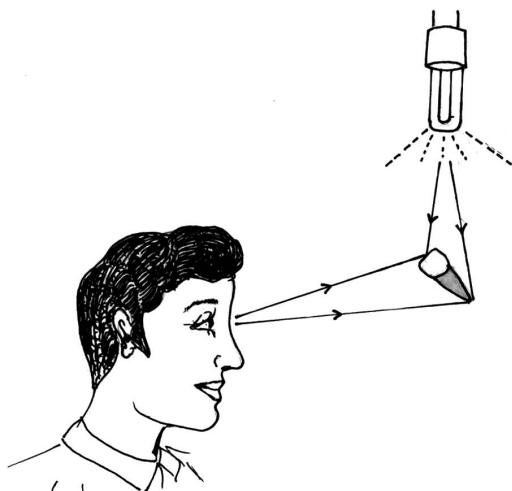
## Color Perception

Balancing illusion with reality is called perception. It is the aspect which is concerned with visualization of the appearance. Various factors are responsible for the perception of color. These are as follows.

- Source of light
  - Surface to be viewed
  - View of observer
- d. Conditions under which the object is viewed.
- Source of light*: The shades of teeth vary in different light conditions. When an object is seen under lights with dominating particular wavelengths (color) bands, the particular color becomes prominent. Therefore, while matching shades, for the best results such source of light should be used which contains full spectrum of rays without the dominance of any wavelength band, like sunlight at noon time when sky is without clouds. Light source used for the color perception should belong to visible light wavelength (380 to 760 nm). Usually direct midday sunlight is the most preferred light for shade selection if the person mostly remains in daylight. If the persons mostly work in bright artificial light, the color matching should be done in same type of artificial light. Other sources of light used are fluorescent lamps, incandescent bulbs and CFL.
  - Surface to be viewed
    - Nature of surface of the object affects the color viewed by determining the optical characteristics of absorption, reflection and transmission.
    - Surface analysis is done with the help of a device called spectrophotometer. This device

breaks the light source into a series of monochromatic beams which are then directed onto the surface of the object.

- c. *View of observer:* Colors and shades should always be compared from the same angle of view and illumination (Fig. 7.2)



**Fig. 7.2:** Color perception. Color perception differs in different individuals

- d. *Conditions under which the object is viewed:* They include
- The condition of oral cavity- Dryness or wetness of oral cavity. In normal conditions tooth is covered with a thin layer of saliva. Hence, while matching the shade, the natural teeth and the shade tabs of the shade guide should also be covered with a thin layer of same saliva of the patient.
  - Angle of illumination.
  - Intensity of illumination.

## DIMENSIONS OF COLOR

Color is represented by three dimensions hue, chroma and value.

### Hue

Type of color means hue. It is that quality of color by which we can distinguish one color from another.

### Chroma

It is the concentration of color. It is the quality of color by which we can distinguish the intensity of color. It can be said that it is a saturation or intensity of hue. With the help of this quality we can distinguish a strong color from a weak one, for example, red is more saturated (stronger) than pink which is less saturated or weak.

### Value

This quality describes the lightness or darkness of color. We can distinguish a light color from dark color. It is the most important dimension while matching a color, as improper value of a restoration can be easily depicted by any ordinary person who is untrained in color perception even from a greater distance when compared to hue and chroma, which are difficult to quantify as viewing distance increases.

Younger teeth are usually much whiter than the older teeth, therefore, restorations like porcelain used in younger teeth should consist of more whitening agents.

### Color System

**Munsell color system:** This system describes hue, chroma and value. It was proposed by Albert H. Munsell and is known as Munsell color system. Most of the shade guides used in dental practice are based on this system which includes color range of the natural teeth.

### Optics of Natural Tooth

**Enamel:** Enamel is made up of both inorganic and organic constituents with 96 percent inorganic matter, which mostly presents as hydroxyapatite crystals. Also fluoroapatite, calcium carbonate and calcium fluoride are present in very little amounts. These crystals are arranged into rods which are held together by organic matrix (collagen). Enamel is more translucent in comparison to dentin, and is formed of translucent rods with outer end on the teeth surface and inner end adjacent to dentin.

**Dentin:** Inorganic content of dentin is less than enamel. It contains around 70 percent of inorganic materials, mainly hydroxyapatite crystals. Organic content is chiefly collagen and constitutes around 20 to 25 percent of

## 66 Textbook of Operative Dentistry

weight, rest is water. As light transmission is decreased because of increase in the area, there is difference in refractive index, thus, dentin is less translucent.

### Shade Selection

To produce life-like shade of a restoration, polychromatism is essential. Shades of the enamel and dentin should be analyzed and the interface should be invisible. True shade is represented in only the middle third of the tooth. This is the main area against which the shade is matched.

For proper shade selection the correct sequence is as follows.

1. Basic shade
2. Basic shade variations
3. Enamel shade, translucency and location
4. Special effects.

For improving smile and esthetics it is better to start from posterior teeth. For improving shade it must be ascertained that which opaques and shade modifiers would improve the present shade by changing value and chroma. Now-a-days materials are available which can very much improve smile and esthetics.

The color of a natural tooth is primarily due to dentin. Rays reflected from it are transmitted via enamel depending upon the thickness and degree of enamel translucency. There is variation of color and shade, thus dividing the tooth in 3 parts [incisal third, middle third and cervical third] on the basis of color variation. Thus, this color variability should be kept in mind while selecting a shade of a restoration, specially porcelain using translucent opaque, enamel and dentin porcelain.

- a. Incisal third of tooth is light bluish in color because it is primarily composed of translucent enamel.
- b. Middle third of tooth is light creamy yellow, bluish yellow, grayish yellow in color as it is mainly composed of dentin and color determination is done by dentin and modified by translucent enamel.
- c. Cervical third of tooth is light to dark yellow, orange-yellow, yellow to light brown in color, as enamel is extremely thin and underlying dentin is more visible in this region.

### DENTAL SHADE GUIDES

Dental shade guides are the aids to help selection of the most acceptable color and shade matching with the

tooth or teeth to be restored. Shade guides are primarily based on Munsell color order system.

- a. Color space is one, in which each color is the center of a sphere of colors, and the next closest match in color surrounds it. Ideally for any shade guide, there should be adequate arrangement and distribution of various shades in color space.
- b. Shade guide provided by a manufacturer along with the material should be used for that material only, and not for materials provided by other manufacturers.
- c. Shade guides can be of two types. (i) key ring guides and (ii). metal slotted type fixed in plastic holders like vita shade guide (Fig. 7.3) Latter are more convenient.



Fig. 7.3: Vita lumin—Vacuum shade guide

- d. However, there are following limitations regarding use of shade guides:
  1. Shade button never matches a natural tooth in terms of optical characteristics.
  2. Thickness of plastic or porcelain tab may be different from the prosthesis being made producing light shade difference.
  3. Artificial plastic teeth when thick usually appear darker in shade and appear lighter in shade when in thin layer, for example, after grinding.
  4. Size and surface texture of a tooth and shade button may not be in harmony.

### GUIDELINES FOR CLINICAL SHADE SELECTION

The following guidelines should be followed while selecting a shade for tooth restoration.



1. *Operating site lighting:* Sunlight in the middle of day is considered optimal for shade selection as this exposure contains almost equal blend of all wavelengths of light compared to morning and evening exposure, which are rich in reddish yellow wavelengths.
  - a. As all clinics may not have proper access to sunlight, thus artificial light should be used in the clinics to simulate the sunlight.
  - b. No artificial light lamp is able to perfectly duplicate the sunlight, but they are satisfactory for clinical purposes.
  - c. Color Rendering Index: (CRI) is used to measure the capacity of artificial light to reproduce natural light. CRI for white light is 100.  
Any light source used for color matching should match this assigned CRI, but rarely any artificial light is available with this range. Hence, artificial sources with an index over 90 are considered adequate.
  - d. Before going in for a shade selection, it should be ascertained as to which light the patient is most exposed to, in his/her daily routine. Those lights should be selected which closely resemble patient's working conditions. The film actors and models are exposed to bright lights, hence the color matching for them should be done in same type of lights.
2. *Environment*
  - a. Bright colored surroundings should be avoided as they interfere with the proper color matching by influencing the colors in the reflected light.
  - b. A drape can be used to mask an undesirable color in patient's clothing and jewellery. Lipstick shades rarely used should be removed so that it may not affect the perceived colors. The shade of the lipstick routinely used may be used during shade matching also.
  - c. Very light gray is the ideal background for color matching. Surfaces with high gloss produce disturbing glares and should be avoided.
3. *Condition of the teeth*
  - a. Tooth in question and the adjoining teeth should be free of plaque and all other deposits and surface stains.
  - b. Tooth should be moist with saliva, as is routine while selecting a shade, as dehydration results in a whiter appearance.
    - i. As a result of dehydration, there is loss of loosely bound water from enamel due to which there is increase in the internal scattering of light and thus the amount of reflected light reaching the operator is increased.
    - ii. Color should be matched before applying a rubber dam as it may interfere with shade selection, as the tooth will become dry after application of rubber dam.
4. *Distance of an operator from tooth:* Usually 61 cm (2 feet) to 183 cm (6 feet) distance from the oral cavity is ideal for shade matching.
5. *Position of patient*
  - a. Position of patient in a dental chair should be such that his teeth should be at the level of operator's eyes
  - b. Operator should stand directly in the front of patient while light is focussed on the teeth, during shade selection.
6. *Time factor:* Sufficient importance should be devoted for the shade selection. As time factor is important for shade selection and shade matching, these should be performed at morning time, when eye fatigue has not set in due to dental procedures.
7. *Squint test for restricting light*
  - a. Squint test is performed for shade selection. This test enables the shade selection by restricting the light entering the eye.
  - b. It is done by bringing the eyelids closer and looking at a shade guide and the natural tooth, the color that fades from the view first is the one that is least conspicuous in comparison with the color of the tooth.

## SHADE MATCHING

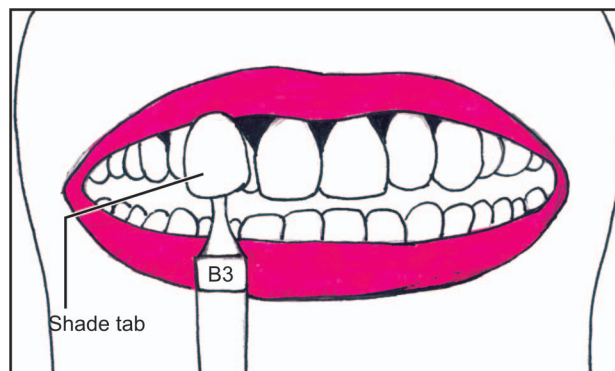
- a. Following is the procedure of shade matching for porcelain restoration which enables the use of Vita shade guide, which is helpful in improving the accuracy of shade matching.
- b. Shade Indicator chart is helpful in determining the required shade of porcelain restoration.
- c. An identification shade tab is fabricated which allows visual confirmation of selected shades of porcelain.
- d. All the basic guidelines for the shade selection, which are described earlier in this chapter, should be followed.



## 68 Textbook of Operative Dentistry

- e. Bleaching procedures if required should be followed prior to shade selection.
- f. Color and shade is being selected using Vita shade guide, Vita VMK shade indicator chart and ring tabs, etc.
- g. Vita shade guide—It is most commonly used and consists of individually fired buttons of opaque dentin and incisal porcelain which are about 1 to 2 mm thick.
- h. Shade guide is arranged according to the hue. There are 4 basic hues—A, Brownish tone B, Yellowish tone C, Gray tone and D, Reddish tone. They are further subdivided into divisions like  $A_1, A_2, A_3, A_4$ , which represent chroma. Same is with B, C and D.
- i. At first, hue is selected using the four hues technique, as there is not much difference among different hues.
- j. Maximum chromas of each hue, i.e.  $A_4, B_4, C_4$  and  $D_4$  are selected and placed at equal distances in the Vita “Individual’s kala kit” which allows to visualize the difference in hues because chromas of maximum intensity are placed besides each other.
- k. Closest matching shade is selected by observing the shade guide against cervical part of tooth. Shade should be selected within 5 seconds to avoid fatigue of eyes.
- l. After hue has been selected, then chroma is selected by placing different chromas of selected hue in the “individual’s kala kit”.
- m. Each Shade tab is placed one by one alongside the tooth to be restored and the shade is selected by comparing the tab against the centre of the tooth (Fig. 7.4).
- n. Important guidelines which help in selecting a chroma are as follows
  1. Chroma is similar in maxillary incisors and premolars, with central incisors being lightest.
  2. Mandibular incisors in comparison to maxillary incisors are usually one chroma lighter.
  3. Canines are two chroma darker than maxillary incisors.

After selecting a chroma, shade indicator chart is used to check the matching dentin color. Finally closer number of dentin chroma is recorded by checking in dentin ring tabs (Fig. 7.4). Next, enamel color is confirmed

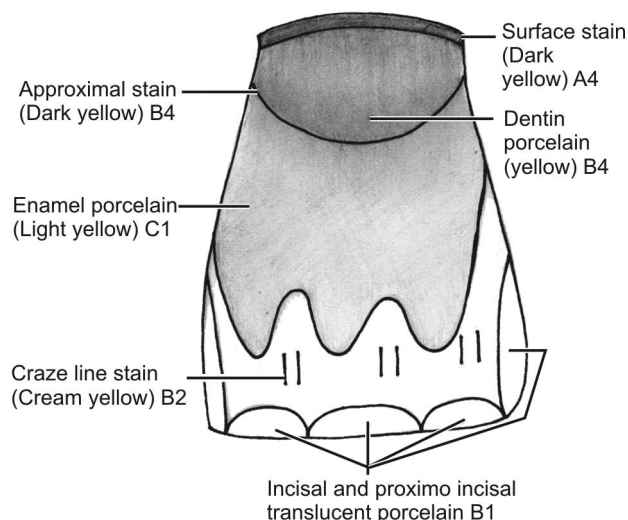


**Fig. 7.4:** For selection of shade, shade tab is held along side the tooth to be restored

using enamel ring tab. Another shade guide which is arranged according to value is used to select a value. If it is difficult to select a hue and if choice has to be made between a lighter and darker hue then comparatively darker hues are selected. If difficulty arises in matching a chroma and value, then a shade is chosen which has lower chroma and higher value. For the tooth which exhibits multiple color characteristics, the shade matching is done separately for middle and incisal one-third.

Methods to get information necessary to obtain an esthetic ceramic restoration are the following:

1. Surface texture
2. Esthetics prescription form
3. Identification tab
4. Characterization map.
  1. *Surface texture:* Recording and communicating surface texture is very important. The surface texture should have a natural appearance. Texture of surface decides the value. Smooth surfaces have specular reflection while rough surfaces have diffuse reflection. Age should be kept under consideration while designing a surface
  2. *Esthetic prescription:* It is a prescription from the dental surgeon to the laboratory. It enables the dental surgeon to direct to the laboratory any modifications in shade and tooth arrangements and also guide for shade selection in different parts of tooth (Fig. 7.5).
  3. *Identification tab:* Identification tab is a simple method for visualizing the end results. Any alterations according to patient's desire can be



**Fig. 7.5: Esthetic prescription (facial view)**—The location and pattern of various characteristics of porcelain jacket crown like incisal and proximo incisal translucency, craze lines, various shades and stains (Vita Lumin Vacuum shade guide)

made before the 'final try in' with the help of identification tab.

4. **Characterization tab:** It is a method for making special effects like hypocalcification or hypercalcification (translucency) characterization patterns. This is done when hypocalcification or translucency patterns are desired to be duplicated in a ceramic restoration.

### Margin Marking of the Visible Restorations

In the easily visible restorations the junction of the tooth with the restoration are the critical areas. To make this area invisible an opaque composite is carefully applied at the junction. This opaque composite may be a mixture of opaque and body shade. To further mask the junction special effects by applying tints may be created.

### Porcelain Staining

Ceramic staining is done with the help of colors (metallic oxide pigments) in order to match the restoration with natural teeth. These pigments have similar composition as colorants used in opaque and body porcelain but

may vary in quality, quantity and the size of pigment. Stains can be used on either glazed or unglazed surfaces, but results are better when used on unglazed surface as they may penetrate deeper creating a more diffused appearance. Stains should always be applied on clean and clear surface devoid of any contaminants.

### Tooth Shade System (Vita Easy Shade)

This device is for electronic measurement for the determination of tooth shades. The tooth of which the shade is to be taken is scanned by the optical unit calibrated and results are electronically converted to the programmed color data. It can be used as the sole means of determining tooth shades. The unit is simple to operate and consists of a handpiece with cable for optical scanning and an electronic unit with an easily readable display. The color spectrophotometer is easy to handle and is ready for use in seconds. The tooth for which the shade is to be determined is scanned by the optical unit, calibrated and the results are converted electronically to the programmed color data.

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# 8

## Nomenclature, Classification and Fundamentals in Cavity (Tooth) Preparation

### INTRODUCTION AND DESIGNATION OF TOOTH SURFACES

The clinician must be very well familiar with the identification of teeth, their various surfaces and terminology used during the treatment procedures, etc. Nomenclature is a group of terms specific to the science that must be understood before communication can be established. Operative dentistry requires essential knowledge of basic cavity (tooth) preparation, which is important to the dental practitioner. Terminology is primarily concerned with instrumentation and cavity preparations. The most important fundamental procedure of operative dentistry is cavity preparation to receive a restoration so that it can fulfill all its requirements. Therefore, it is a must for every operative clinician to be well aware of all the fundamentals of the cavity preparation. A cavity is a defect in the mineralized dental tissues which results from pathological processes like caries, attrition, abrasion and erosion.

The cavity preparation includes all mechanical procedures performed to remove all infected and affected tissues and to give proper design to the remaining hard dental tissues, so that a mechanically and biologically sound restoration can stay in the prepared cavity. Cavity preparation is a surgical procedure that removes the caries till the sound tooth tissue of proper shape that will retain the restorative materials, which resist the masticatory forces, is reached.

Coronal portion of each tooth is divided into surfaces that are designated according to their related anatomic structures and landmarks (Fig. 8.1).

*Buccal*—Towards the cheek  
*Labial*—Towards the lip  
*Mesial*—Towards the anterior midline  
*Distal*—Foremost (most distant or distal) from anterior midline

- Lingual/Palatal* - Towards the tongue, in maxillary teeth the surface towards the palate are also called palatal
- Occlusal* - Masticating surfaces of premolars or molars (posterior teeth)
- Incisal* - Cutting edges of anterior teeth (incisors and canines)
- Gingival* - Nearest and towards the gingiva
- Cervical* - Nearest and towards the cervix or neck of the tooth

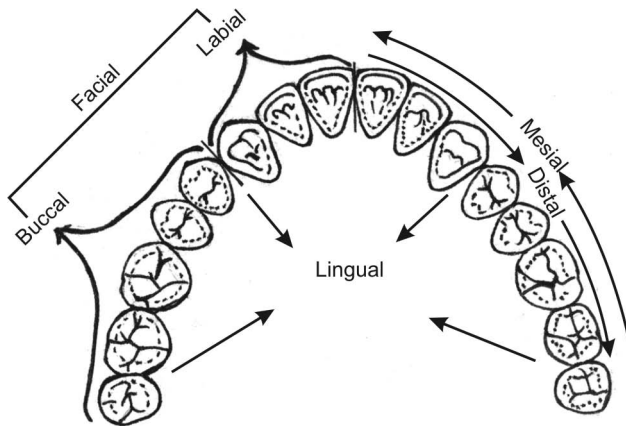
The tooth surfaces can be numbered or designated by first letter of surface to simplify the describing of the location of caries for charting and recording as follows:

|                             | Number | Letter  |
|-----------------------------|--------|---------|
| <i>Mesial</i>               | 1      | M       |
| <i>Distal</i>               | 2      | D       |
| <i>Facial/Buccal/Labial</i> | 3      | F/B/Lab |
| <i>Lingual/Palatal</i>      | 4      | L/P     |
| <i>Occlusal/Incisal</i>     | 5      | O/I     |

### REQUIREMENT FOR RESTORATION AND PURPOSE OF CAVITY PREPARATION

The need for restoration is to repair a tooth after destruction mostly from caries. The restoration may be required in all cavities so that tooth can perform proper function. Another occurring need is the replacement or repair of restoration in secondary caries. Restorations are also indicated to restore proper form and function to fractured teeth. It should be completely understood that restorative procedure primarily repairs the damage caused by caries and other destructive processes.

The purposes of cavity preparation are as follows:  
 (1) Removal of all the defects of enamel, dentin and



**Fig. 8.1:** Tooth surface designations as seen from incisal/occlusal view

cementum with protection of pulp, (2) To locate the margins of restoration as conservatively as possible (3) To allow for esthetics and functional placement of restorative material (4) Design of cavity should be such that cavity and restoration can withstand the forces of mastication.

Dr GV Black laid the scientific foundation based on these objectives. From the year 1898 to 1988 for 90 years Black's principles of cavity preparation formed the basis of most operative procedures. Later on due to the improvements and success in the following, Black's principles of cavity preparation were modified.

- Oral hygiene procedures.
- Preventive procedures of dental caries.
- Existing and development of new relatively more and more adhesive restorative materials.
- Instruments and equipment.

Modifications in Black's principles have resulted from the work of Markley, Sockwell, Simon Sturdevant, Mount, Sikri and Chandra and Chandra (given in this chapter).

## TERMINOLOGY OF TOOTH (CAVITY) PREPARATION

### Tooth (Cavity) Preparation

It is a mechanical alteration of a tooth to make it disease free and/or to give it such a shape that it can retain the

restorative material which will maintain the original morphology of tooth and provide proper function and esthetics. In the tooth preparation, remove all the diseased tooth structure avoiding pulpal exposure. When the carious dentin remains at the time of placing restorative material it may result in further caries progression, pain, sensitivity and fracture of restoration and even the tooth. The tooth is prepared in such a manner so as to ensure the placement of margins of the restorative material into accessible areas, sufficient retention for restorative material, and protection of vital pulp organ.

### Simple, Compound and Complex Cavity Preparation

A cavity preparation involving only one tooth surface is termed simple cavity. If two surfaces are involved it is termed compound cavity, whereas if more than two surfaces are involved it is called as *complex cavity* preparation.

### Cavity Preparation Walls

**Internal wall:** It is a wall in the prepared cavity, which is not extended to the external tooth surface.

**External wall:** An external wall is a wall in the prepared cavity surface that extends to the external tooth surface, and this wall takes the name of the tooth surface towards which it is situated.

**Pulpal wall:** A pulpal wall is an internal wall that is towards the pulp and covering the pulp. It may be both vertical and/or perpendicular to the long axis of tooth and occlusal/mesial/distal/buccal/lingual to the pulp depending upon class, division and subdivision of the cavity.

**Axial wall:** It is an internal wall which is parallel to the long axis of the tooth.

**Floor:** It is a prepared cavity internal wall, which is usually flat and perpendicular to the occlusal forces directed occlusogingivally, for example, pulpal and gingival walls. Such floors or seats are prepared to provide stability seats for restoration that distribute the stress in the tooth structures.

### Cavosurface Angle Margin and Cavity Margin

Cavosurface angle is formed by the junction of a prepared cavity wall and external surface of the tooth.



## 72 Textbook of Operative Dentistry

The acute junction is referred to as cavity margin or cavosurface margin. The cavosurface angle may differ with the location of tooth and enamel rod direction of the prepared walls and also differ according to the type of restorative material to be used.

### Line Angle

It is a junction of two surfaces of different orientations along the line and its name is derived from the involved surfaces.

### Point Angle

It is a junction of three plane surfaces or three line angles of different orientation and its name is derived from its involved surfaces or line angles.

The line angles and point angles of different cavity designs are as follows:

An occlusal class I cavity has four surrounding walls or surfaces.

*Distal wall*

*Mesial wall*

*Facial wall*

*Lingual wall*

Class II (mesio-occlusal) preparation on posterior teeth has six surrounding walls -

*Distal wall*

*Lingual wall*

*Facial wall*

*Pulpal wall*

*Axial wall*

*Gingival wall*

For proximal class III preparation

*Facial wall*

*Lingual wall*

*Gingival wall*

Incisal angle (mostly it is incisal angle occasionally it may be wall).

For simple class I cavity preparation involving only occlusal surface of molars eight line angles and four point angles have named as follows:

- Line angles
- *Mesiofacial line angle*
  - *Mesiolingual line angle*
  - *Distofacial line angle*
  - *Distolingual line angle*
  - *Faciopulpal line angle*
  - *Linguopulpal line angle*
  - *Mesiopulpal line angle*
  - *Distopulpal line angle*

- Point angles
- *Mesiofaciopulpal point angle*
  - *Mesiolinguopulpal point angle*
  - *Distofaciopulpal point angle*
  - *Distolinguopulpal point angle*

For class II cavity preparation (mesio-occlusal or disto-occlusal) 11 line angles and 6 point angles are as follows. The following is the nomenclature for mesio-occlusal cavity. In disto-occlusal cavity 'Disto' will be replaced by 'Mesio'.

- Line angles
- *Distofacial*
  - *Faciopulpal*
  - *Axiofacial*
  - *Faciogingival*
  - *Axiogingival*
  - *Linguogingival*
  - *Axiolingual*
  - *Axiopulpal*
  - *Distolingual*
  - *Distopulpal*
  - *Linguopulpal*

- Point angles
- *Distofaciopulpal point angle*
  - *Axiofaciopulpal point angle*
  - *Axiofaciogingival point angle*
  - *Axiolingugingival point angle*
  - *Axiolingupulpal point angle*
  - *Distolinguopulpal point angle*

**Clinically Caries is of the following two types:**

### Pit and Fissure Caries

This type of caries begins at the site of developmental irregularities. If incomplete coalescence of enamel has taken place, it results into the pit and fissure cavity. The pit and fissure lesion usually represents one cone in enamel and another cone in the dentin. The caries forms a small area of penetration in enamel and spreads laterally to a great extent along the dentinoenamel junction.

### Smooth Surface Caries

Smooth surface caries does not begin in an enamel defect and most frequently occurs in protected areas, which are difficult to maintain plaque free. In the smooth surface, caries penetrates the enamel in the form of cone with the base at the enamel surface and its apex at the dentinoenamel junction or towards the pulp.



## **CLASSIFICATION OF PREPARED CAVITIES**

The missing part of tooth structure (cavity) can be classified on the basis of the surfaces involved and its relation to the anatomical structure of the tooth itself. By relating the defects to their clinical location, GV Black in end of nineteenth century, presented a simple cavity classification listed as class I, class II, class III, class IV and class V. An additional class VI was later on added by Simon as modification to Black's classification.

Class I is the only pit and fissure cavity whereas rest are smooth surface cavities.

Class I—Pit and fissure cavities occur in the occlusal surfaces of premolars and molars, the occlusal two-third of buccal and lingual surface of molars, lingual surface of incisors and any other abnormal position.

Class II—Cavities in the proximal surface of premolars and molars,

Class III—Cavities in the proximal surface of anterior (incisors and canine) teeth and not involving the incisal angles.

Class IV—Cavities in the proximal surface of anterior teeth also involving the incisal angle.

Class V—Gingival cavities on gingival third (not pit and fissure cavities) on facial and lingual or palatal surfaces of all teeth.

Modification of Black's classification was made to provide more specific localization of cavities.

Class II—Cavities on the single or both proximal surface of premolar (bicuspid) and molar teeth when cavity involves both proximal surfaces it is called mesio-occluso-distal (MOD) cavity.

Class VI—Cavities on incisal edges of anterior and cusp tips of posterior teeth without involving any other surface.

## **FURTHER MODIFICATIONS OF BLACK'S CLASSIFICATION**

Black's classification was based on the following conditions and considerations prevalent at that time. (1) Poor oral hygiene habits and awareness (2) Hard and fibrous food (3) Low consumption of refined carbohydrates (4) Low incidence of caries (5) The properties of the existing restorative materials (6) The expected longer life of the restoration (7) More liking towards gold and silver fillings in teeth (8) Prevailing popular diagnostic aids.

Most of these conditions have changed. During cavity preparation Black suggested following precautions.

1. Provision for definite mechanical retention in the cavity.
2. Extension into nearby deep pits and fissures for prevention of recurrent caries.
3. Removal of infected and affected enamel and dentin from all surfaces.
4. Removal of even healthy tooth structure to gain access and good visibility
5. Cavo-surface margins must be at self cleansing areas.

With the following changes the designs of the cavities have become most conservative and Black's concepts have been totally revolutionized

1. The development of tooth colored, adhesive, fluoride releasing restorative materials which make adjacent tooth tissues caries resistant.
2. More liking for tooth colored restorative materials.
3. Satisfaction even with shorter life of esthetic restoration.
4. Routine use of improved and new diagnostic aids.
5. Better oral hygiene maintenance.
6. Softer food rich in refined carbohydrates.
7. Use of preventive measures like fluoridation of water supply, fluoride toothpaste, fluoride gel, proper brushing and flossing, etc.
8. Realization of the fact that the remineralization of uninfected demineralized dentin takes place hence it can be left as such.
9. Acid etching followed by bonding provides retention sufficient to hold back the restorative materials.

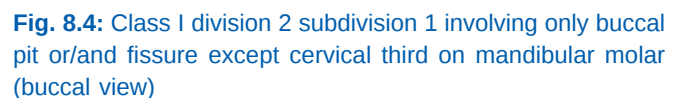
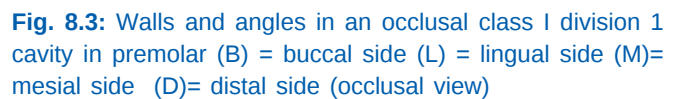
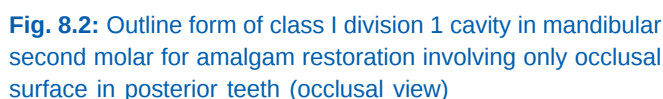
Mechanical retention forms further improve the retention.

In 1998 Mount suggested a classification which was not comprehensive. In 1999 Sikri suggested improvements in Black's classification. Chandra and Chandra classified the complete situation and extent of the cavity and its closeness to the pulp, which is most important for treatment planning. This gives almost the complete picture of the cavity as well as expected treatment planning. For this radiographic evaluation and measurement by Dentinometer or Prepometer (device which estimates the thickness of the remaining dentin towards pulp) are helpful. If dentinometer is not available then radiographic evaluation will be enough.

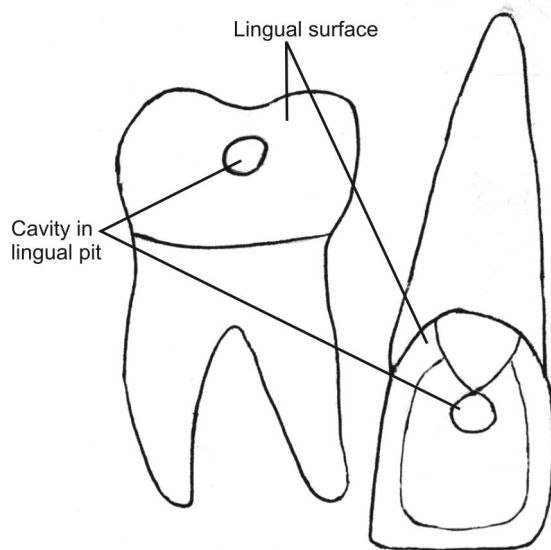
All cavities are classified when they are ready for restoration.

Class I cavities are the cavities involving only pit and fissures, except at cervical third, of all teeth (Figs 8.2 to 8.9).

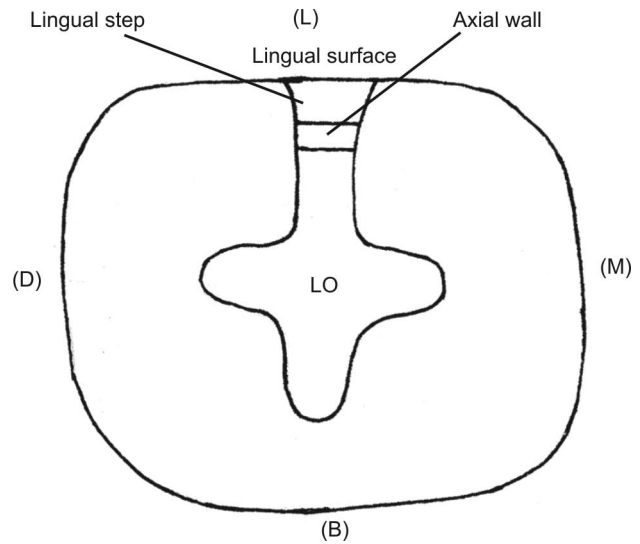
- A. Class I division 1 cavity—These are the cavities involving only pits and fissures of occlusal surfaces of all the posterior teeth (Figs 8.2 and 8.3).
- B. Class I division 2 cavity—These are the cavities involving only facial and lingual pit and/or only facial and lingual fissures, except at cervical third, of all the teeth (Fig. 8.4).



Class I division 2 subdivision 1 cavity—These are the cavities involving only facial pit or/ and fissure except at cervical third (Fig. 8.4) of all the teeth.



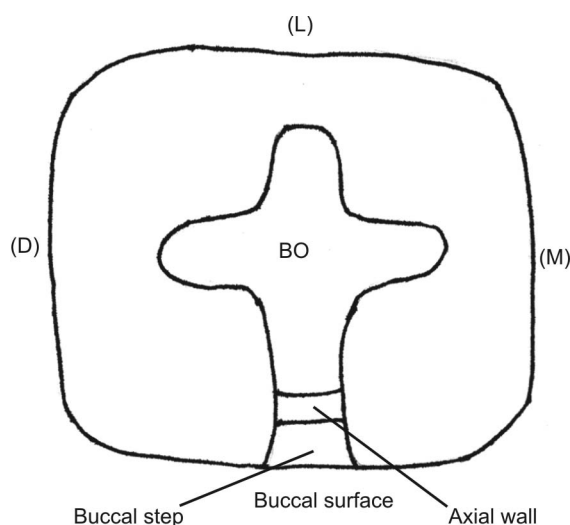
**Fig. 8.5:** Class I division 2 subdivision 2 involving only lingual pit and/or fissure except cervical third only in mandibular molar and maxillary central incisor (lingual view)



**Fig. 8.7:** Class I division 4 cavity in the mandibular molar involving lingual and occlusal surfaces (LO cavity) (occlusal view)

Class I division 2 subdivision 2 cavity—These are the cavities involving only lingual pit or/and fissure except at cervical third (Fig. 8.5) of all the teeth.

- C. Class I division 3 cavity—These are the occlusal pit and fissure cavities united with and also involving buccal pit (BO cavity) and not involving the cervical third, in the posterior teeth (Fig. 8.6).



**Fig. 8.6:** Class I division 3 cavity in the mandibular molar involving buccal and occlusal surfaces (BO cavity) (occlusal view)

- D. Class I division 4 cavity—These are the occlusal pit and fissure cavities involving and also united with lingual pit cavity and not involving the cervical third, in the posterior teeth (Fig. 8.7).

- E. Class I division 5 cavity—These are the occlusal pit and fissure cavities also involving and united with both buccal and lingual pits (BOL cavity) and not involving the cervical third, in the posterior teeth (Fig. 8.8).

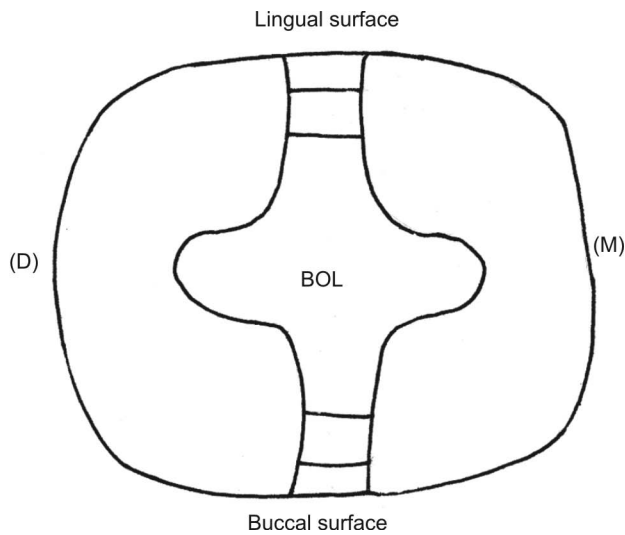
- F. Class I division 6 cavity—These are the occlusal pit and fissure cavities in posterior teeth when capping of the cusp is also required and no other surface other than occlusal is involved (Fig. 8.9).

### Capping the Cusp

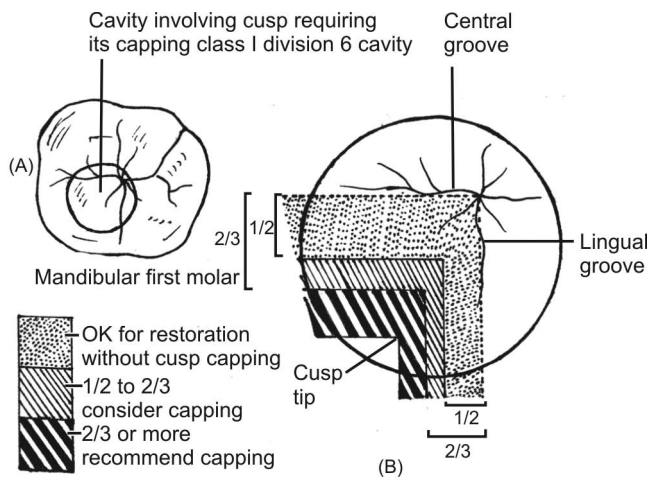
To reinforce the weak cusp it is capped so that it does not fracture under masticatory forces (Fig. 8.9).

### Rule for Cusp Capping

No cusp capping is done when extension of cavity is less than half the distance from the primary occlusal developmental groove to cusp tip. If extension of cavity is half to two-thirds the distance then consider cusp capping. But when extension is more than two-thirds then the cusp is capped depending upon the compressive strength of the restorative material being used (Fig. 8.9).



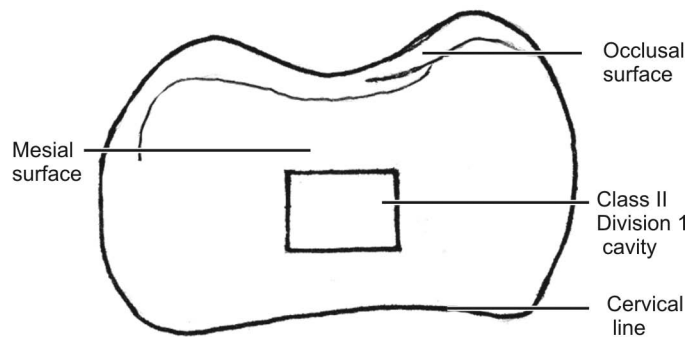
**Fig. 8.8:** Class I division 5 cavity in mandibular molar involving buccal, occlusal and lingual surfaces (BOL cavity) only to form a single cavity (occlusal view)



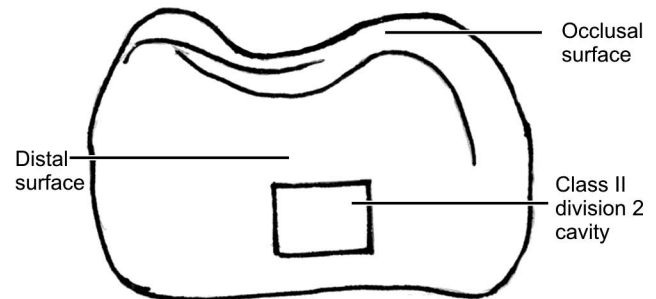
**Fig. 8.9:** Class I division 6 cavity only involving occlusal surface in posterior teeth (A) requiring capping of a cusp (occlusal view) (B) Rule for cusp capping

## Class II

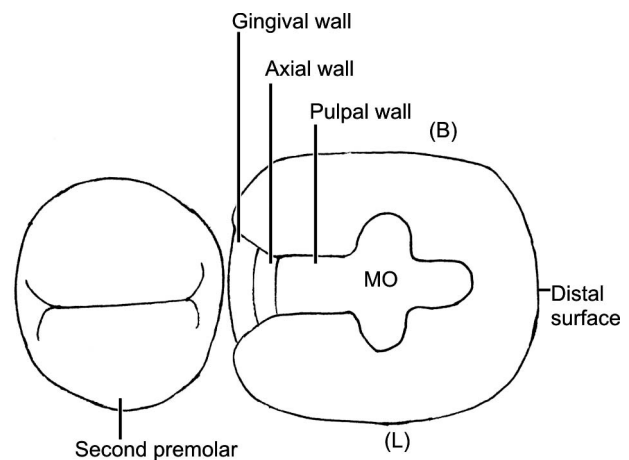
Class II cavities are the cavities essentially on the proximal surface of posterior teeth. These may be mesial, distal, mesio-occlusal (MO), disto-occlusal (DO), and mesio-occlusodistal (MOD) cavities in posterior teeth. Along with proximal surfaces they may also involve buccal and lingual surfaces (Figs 8.10 to 8.24).



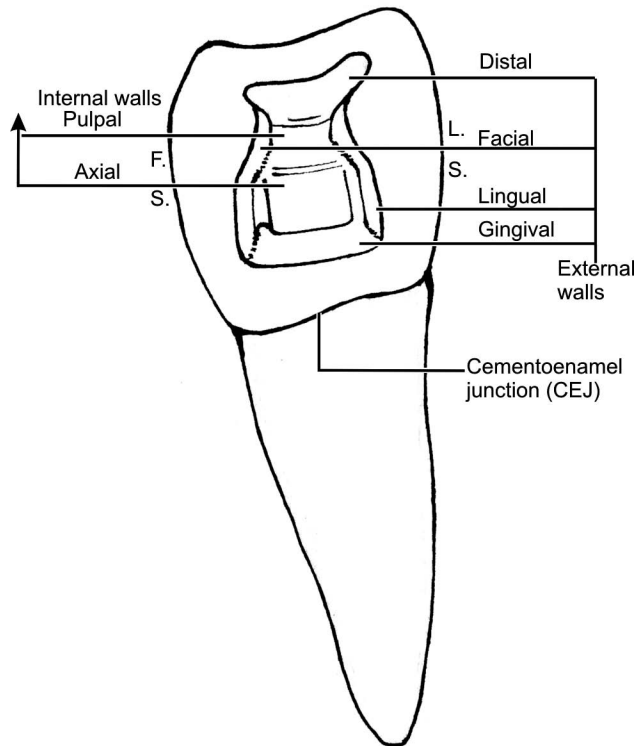
**Fig. 8.10:** Class II division 1 cavity involving only mesial surface of posterior teeth (mandibular first molar) (mesial view)



**Fig. 8.11:** Class II division 2 cavity involving only distal surface of posterior teeth (mandibular first molar) (distal view)



**Fig. 8.12:** Class II division 3 mesio-occlusal cavity (MO). Occlusal view in mandibular first molar

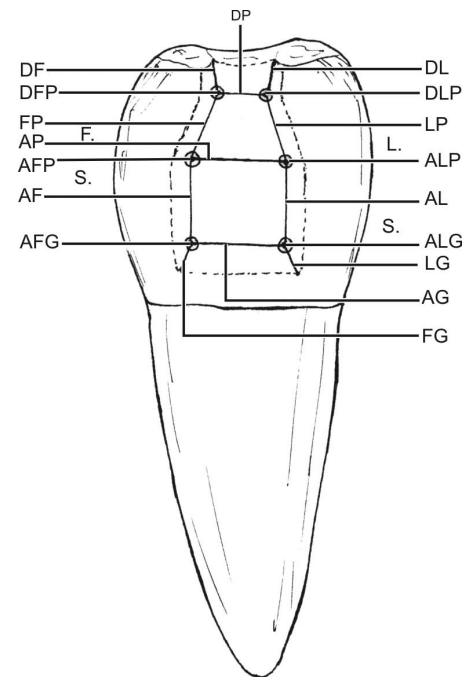


**Fig. 8.13:** Illustration of external and internal walls in class II division 3 mesio-occlusal (MO) cavity in mandibular first molar  
LS = Lingual surface, FS = Facial surface (mesial view)

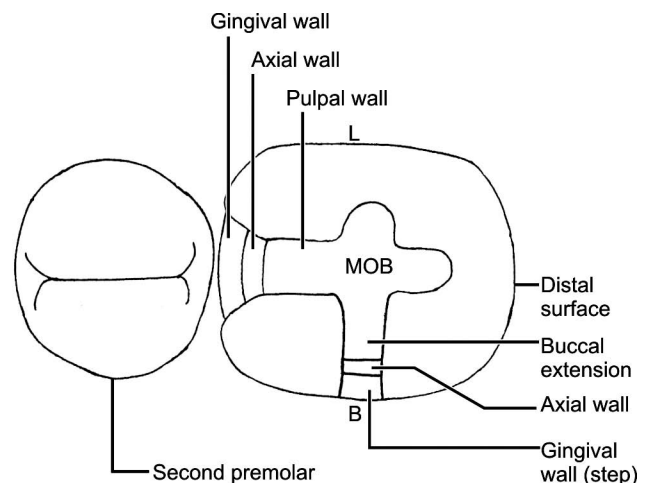
- A. Class II division 1 cavity—These are the prepared cavities involving only mesial surface of the posterior teeth (Fig. 8.10).
- B. Class II division 2 cavity—These are the prepared cavities involving only distal surface of the posterior teeth (Fig. 8.11).

Class II division 1 and division 2 cavities usually occur when the adjacent tooth is extracted out or broken down leaving root stumps and caries is arrested as the area becomes self cleansing.

- C. Class II Division 3—These are mesio-occlusal (MO) cavities in the posterior teeth (Figs 8.12 to 8.14).
  - a. Class II division 3 Subdivision 1—These are mesio-occlusal cavities with extension on buccal surface (buccal step)(MOB) of posterior teeth (Fig. 8.15)
  - b. Class II division 3 subdivision 2—These are mesio-occlusal cavities with extension on lingual surface (lingual step)(MOL) of posterior teeth (Fig. 8.16)

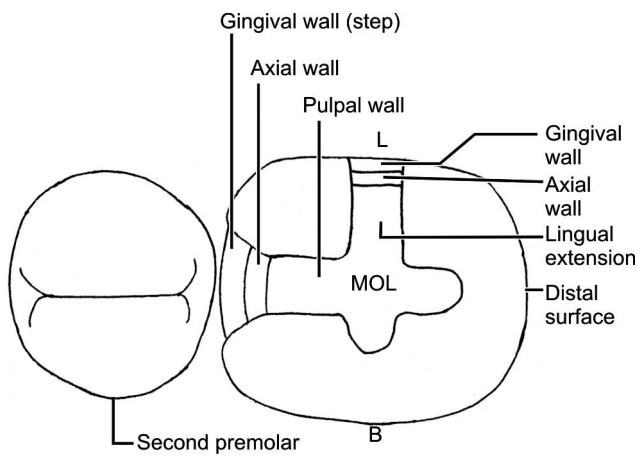


**Fig. 8.14:** Line and point angles in class II division 3 mesio-occlusal (MO) cavity preparation in mandibular molar (mesial view). Distolingual (DL), linguopulpal (LP), axiolingual (AL), linguogingival (LG), axiogingival (AG), faciogingival (FG), axiofacial (AF), axiopulpal (AP), faciopulpal (FP), distofacial (DF), distopulpal (DP). Distolinguopulpal (DLP), axiolinguo-pulpal (ALP), axioliuguogingival (ALG), axiofaciogingival (AFG), axiofaciopulpal (AFP), distofaciopulpal (DFP), two alphabets show line angles and three alphabets show point angles. LS (Lingual surface) FS (Facial or buccal surface)

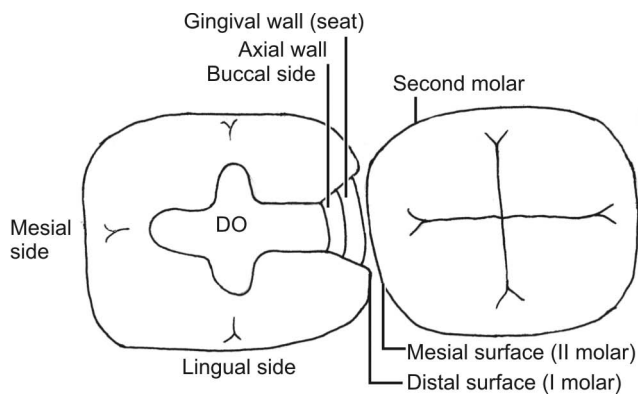


**Fig. 8.15:** Class II division 3 subdivision 1 mesio-occlusal cavity with buccal extension (step) (MOB) on mandibular first molar. (occlusal view) L=Lingual, B=Buccal

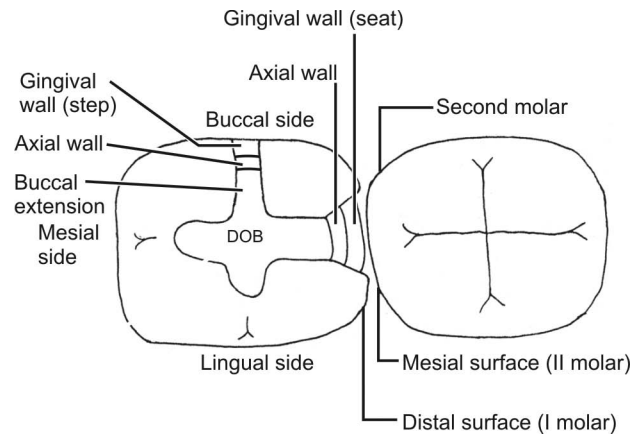




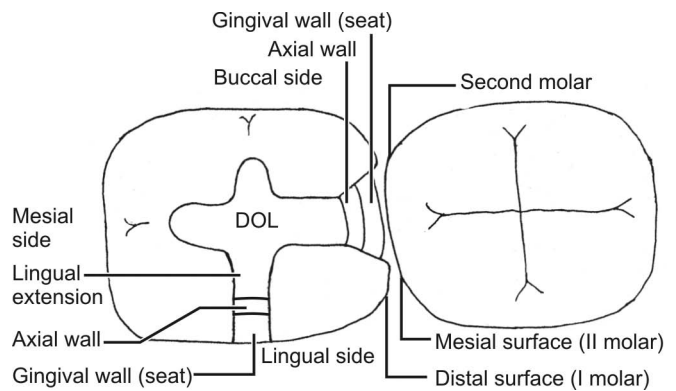
**Fig. 8.16:** Class II division 3 Subdivision 2 mesio-occlusal cavity with lingual extension (step) (MOL) on mandibular first molar (occlusal view) L=Lingual B=Buccal



**Fig. 8.17:** Class II division 4 disto-occlusal (DO) cavity in mandibular first molar (occlusal view)



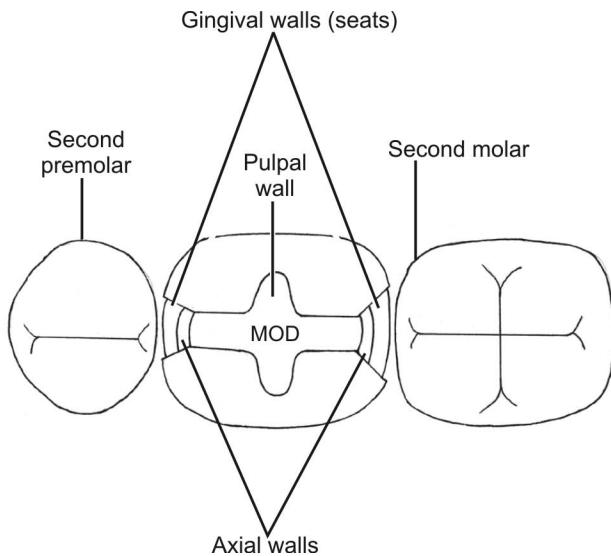
**Fig. 8.18:** Class II division 4 subdivision 1 disto-occlusal cavity with buccal extension (step)(DOB) on mandibular first molar (occlusal view)



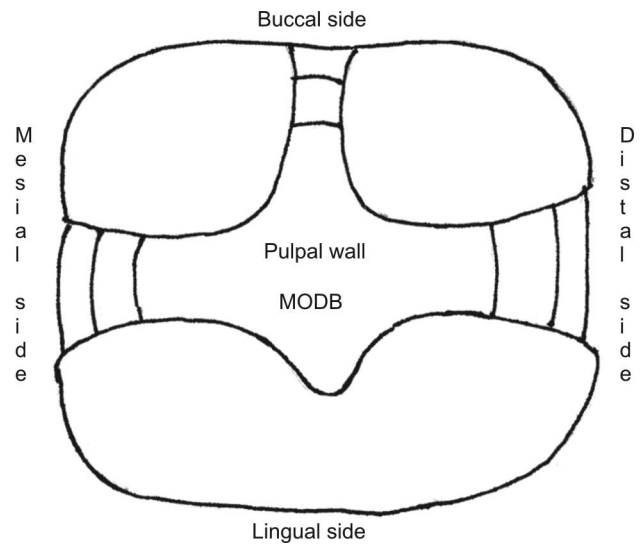
**Fig. 8.19:** Class II division 4 subdivision 2 disto-occlusal cavity with lingual extension (lingual step)(DOL) on mandibular first molar (occlusal view)

- D. Class II division 4—These are disto-occlusal (DO) cavities in the posterior teeth (Fig. 8.17).
- Class II division 4 subdivision 1—These are disto-occlusal cavities with extension on buccal surface (buccal step) (DOB) (Fig. 8.18).
  - Class II division 4 subdivision 2—These are disto-occlusal cavity with extension on lingual surface (lingual step) (DOL) (Fig. 8.19).

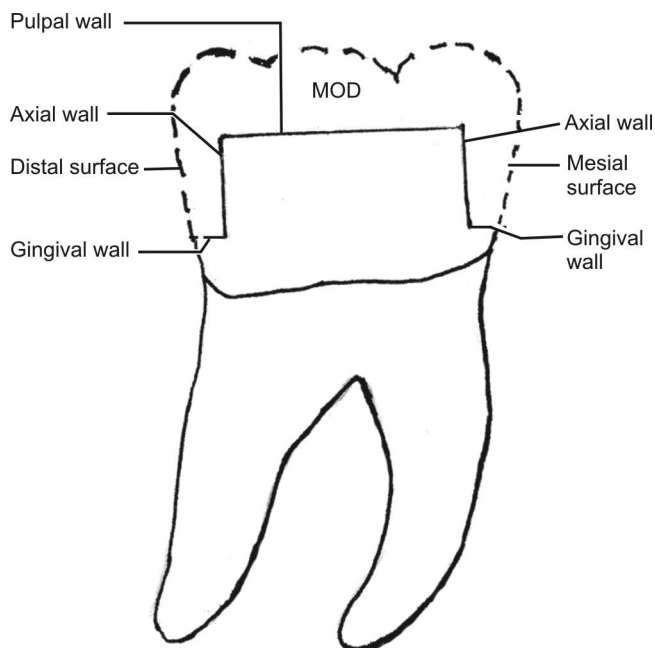
- E. CLASS II division 5 mesio-occlusodistal (MOD) cavity in the posterior teeth (Figs 8.20 and 8.21). Class II division 5 has following subdivisions.
- Class II division 5 subdivision 1—These are MOD in posterior teeth when the buccal surface is also involved (MODB) (Fig. 8.22).
  - Class II division 5 subdivision 2—These are MOD cavities in posterior teeth when the lingual (MODL) surface is also involved (Fig. 8.23)



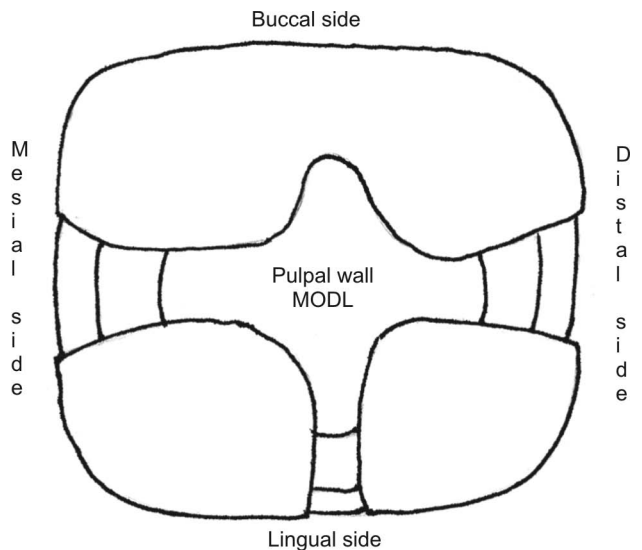
**Fig. 8.20:** Class II division 5 cavity (mesio-occlusodistal) (MOD) in first mandibular molar (occlusal view)



**Fig. 8.22:** Class II division 5 subdivision 1 cavity in mandibular first molar involving occlusal, both proximal and buccal (MODB) surfaces in mandibular molar (occlusal view)

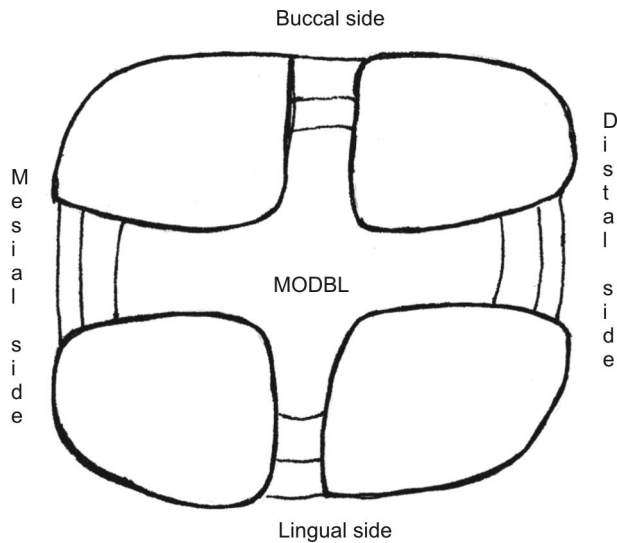


**Fig. 8.21:** Class II division 5 mesioocclusodistal (MOD) cavity in mandibular molar. Buccal view of class II division 5 involving only both proximal and occlusal surfaces in posterior tooth



**Fig. 8.23:** Class II division 5 subdivision 2 cavity in mandibular first molar involving occlusal, proximal and lingual (MODL) surfaces in mandibular molar (occlusal view)

- c. Class II division 5 subdivision 3—These are MOD cavities in the posterior teeth when lingual and buccal (MODBL) both the surfaces are also involved. In total all the five surfaces are involved (Fig. 8.24).

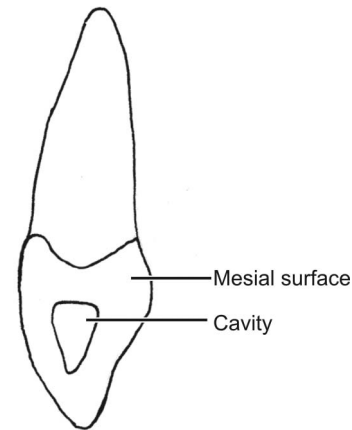


**Fig. 8.24:** Class II division 5 subdivision 3 cavity in mandibular first molar involving occlusal, both proximal and both buccal and lingual (MODBL) surfaces (MODBL) (occlusal view)

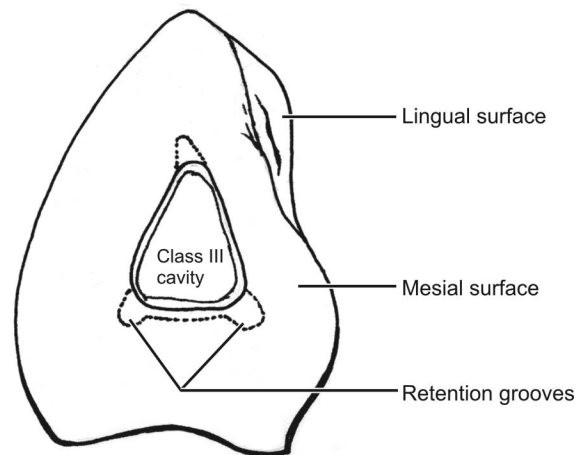
### Class III

Class III cavities are the cavities involving only proximal surfaces of anterior teeth and not involving the incisal angles. Sometimes the proximal lesion has to be approached from the lingual surface in absence of direct approach from proximal side. In such situations the cavity becomes mesiolingual or distolingual, depending upon the surface involved (Figs 8.25 to 8.38).

- A. Class III division I—These are the cavities on mesial surface of anterior teeth (Figs 8.25 and 8.26).
- Class III division 1 subdivision 1 cavities are those cavities which involve only mesial surface in anterior teeth (Figs 8.25 and 8.26).
  - Class III division 1 subdivision 2 cavities are those cavities which involve mesial with lingual (ML) surface in anterior teeth (Figs 8.27 to 8.30).
  - Class III division I subdivision 3 (mesiofacial cavity)—These are the cavities in anterior teeth involving both mesial and facial (MF) surfaces only (Fig. 8.31). 'L' may create confusion between lingual and labial hence 'F' is used for labial (facial).
  - Class III division 1 subdivision 4 (faciomesiolingual cavity)—These are cavities in anterior teeth involving (labial), mesial and lingual (FML) surfaces only (Fig. 8.32)

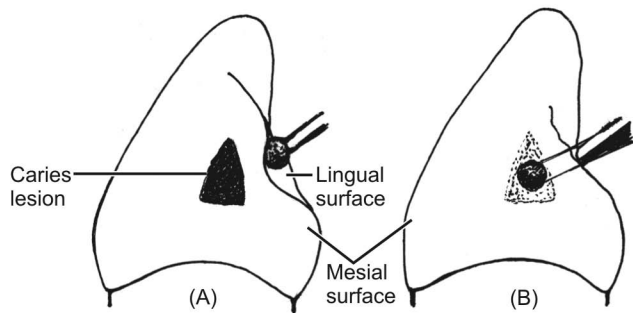


**Fig. 8.25:** Class III division 1 subdivision 1 involving only mesial surface in anterior teeth (mesial view)

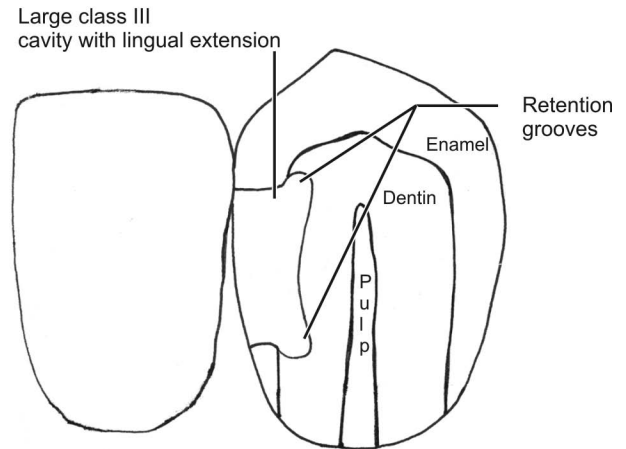


**Fig. 8.26:** Class III division I subdivision 1 on mesial surface with retention grooves on mandibular canine (mesial view)

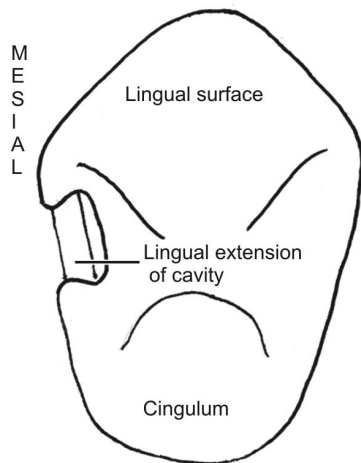
- B. Class III division 2 cavities are cavities on distal surfaces of anterior teeth (Figs 8.33 to 8.36)
- Class III division 2 subdivision 1 cavity (distal cavity only)—These are cavities in anterior teeth involving distal surface only (Fig. 8.33).
  - Class III division 2 subdivision 2 [distolingual (DL) cavity]—These are cavities in anterior teeth involving both distal and lingual surfaces (Fig. 8.34).
  - Class III division 2 subdivision 3 [distolabial or distofacial (DF) cavity]—These are cavities in the anterior teeth involving distal and labial (facial) surfaces (Fig. 8.35).



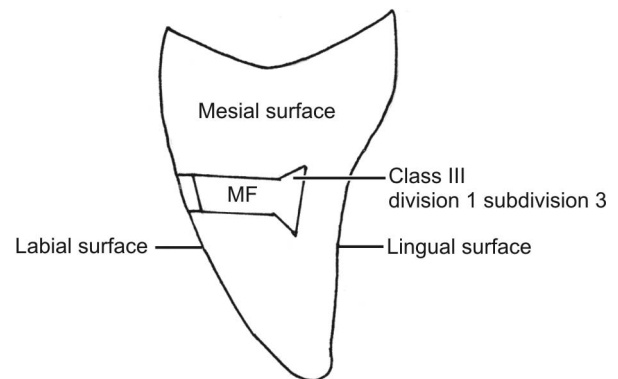
**Fig. 8.27:** Mesial view of class III division 1 subdivision 2 involving both mesial and lingual (ML) surfaces in mandibular canine (A) Lingual approach (B) Caries lesion reached through lingual approach



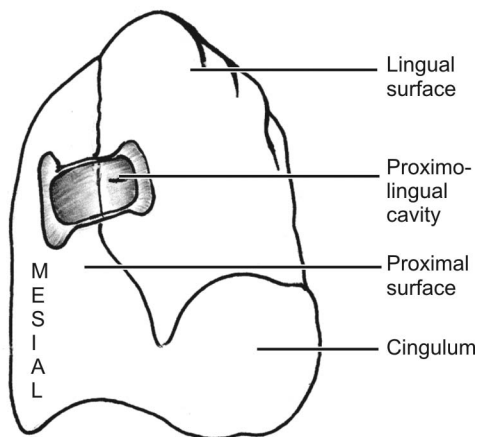
**Fig. 8.30:** Retention grooves in class III division 1 subdivision 2 involving both mesial and lingual (ML) surfaces only (lingual view) in mandibular canine



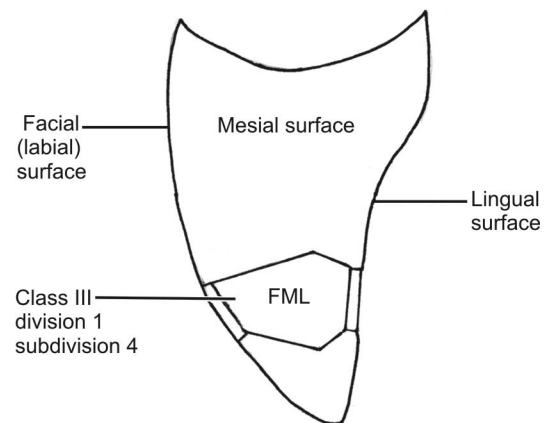
**Fig. 8.28:** Lingual view of class III division 1 subdivision 2 involving both mesial and lingual (ML) surfaces only, in mandibular canine



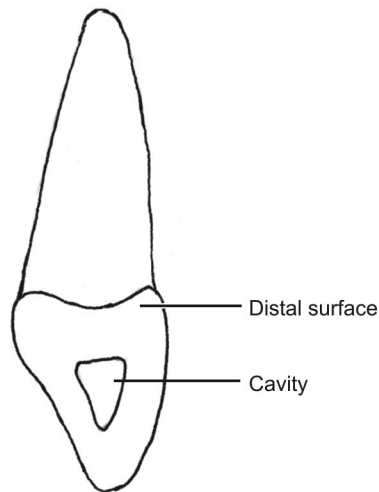
**Fig. 8.31:** Class III division 1 subdivision 3 (mesiofacial) (MF) in maxillary central incisor (mesial view)



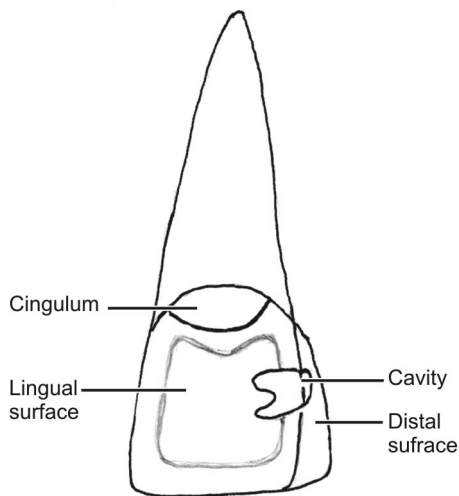
**Fig. 8.29:** Proximo-lingual view of class III division 1 subdivision 2 involving both mesial and lingual (ML) surfaces only, in mandibular canine



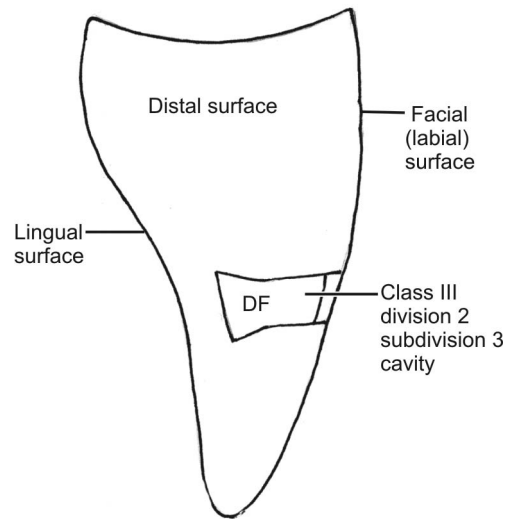
**Fig. 8.32:** Class III division 1 subdivision 4 (faciomesiolingual cavity) (FML) in maxillary central incisor (mesial view)



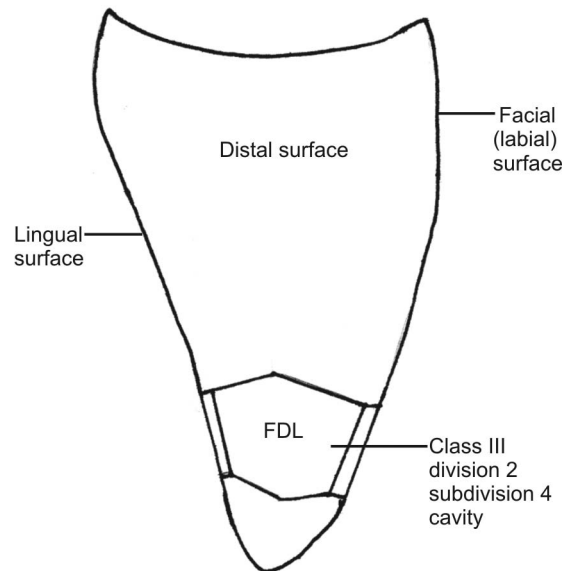
**Fig. 8.33:** Class III division 2 subdivision 1 on distal surface involving only distal surface of maxillary central incisor (distal view)



**Fig. 8.34:** Class III division 2 subdivision 2 cavity on distolingual (DL) surfaces involving both distal and lingual surfaces of maxillary central incisor (lingual view)



**Fig. 8.35:** Class III division 2 subdivision 3 [distofacial (DF) cavity in maxillary central incisor] (distal view)



**Fig. 8.36:** Class III division 2 subdivision 4 (faciodistolingual) (FDL) cavity in maxillary central incisor (distal view)

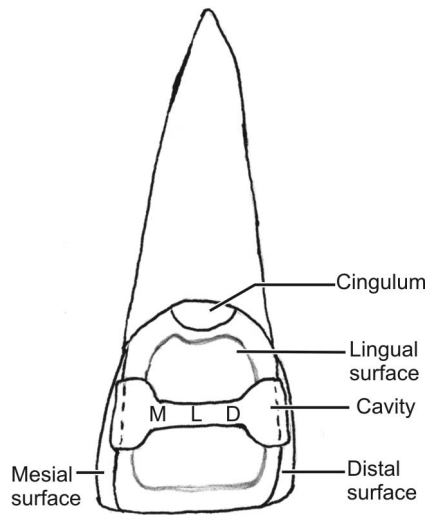
- d. Class III division 2 subdivision 4 (faciodistolingual) cavity—These are cavities in anterior teeth involving labial (facial), distal and lingual (FDL) surfaces (Fig. 8.36).
- C. Class III division 3 (mesiolinguodistal) cavity—These are cavities in anterior teeth involving mesial, lingual and distal (MLD) surfaces only (Fig. 8.37).
- D. Class III division 4 (mesiofaciodistal) (MFD) cavity—These are cavities involving mesiofaciodistal surface of the anterior teeth (Fig. 8.38).

## Class IV

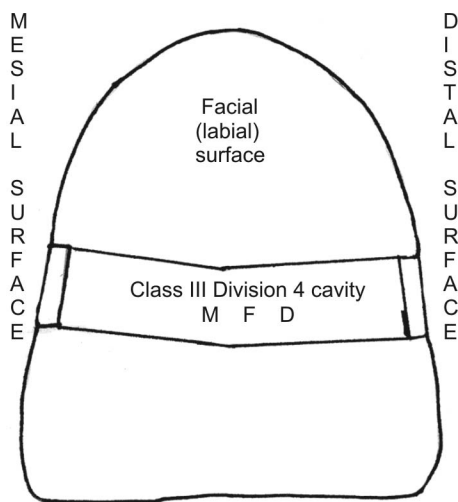
Cavities involving incisoproximal angles of anterior teeth are class IV cavities (Figs 8.39 to 8.44).

- A. Class IV division 1 cavity- These are the cavities involving only mesial incisoproximal angle of anterior teeth (Figs 8.39 to 8.41).



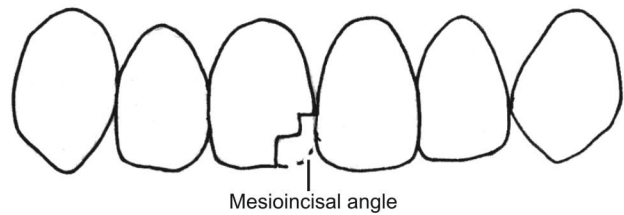


**Fig. 8.37:** Class III division 3 on mesiolinguodistal (MLD) surfaces involving both proximal and lingual surfaces in maxillary central incisor (lingual view)

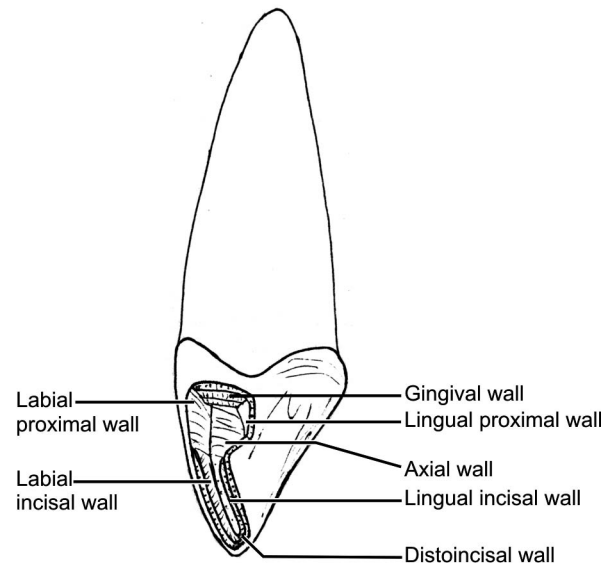


**Fig. 8.38:** Class III division 4 (mesiofaciodistal) (MFD) cavity involving mesiofaciodistal surfaces of maxillary central incisor (facial view)

- B. Class IV division 2 cavity—These are cavities involving only distoincisoproximal angle of the teeth (Fig. 8.42).
- C. Class IV division 3 cavity—These are the cavities which are class IV cavity on one proximoincisor angle and class III cavity on another proximal side and



**Fig. 8.39:** Class IV division cavity I involving only mesioincisal (MI) angle of maxillary central incisor (facial view)



**Fig. 8.40:** Class IV division 1 cavity (mesial view) in maxillary central incisor

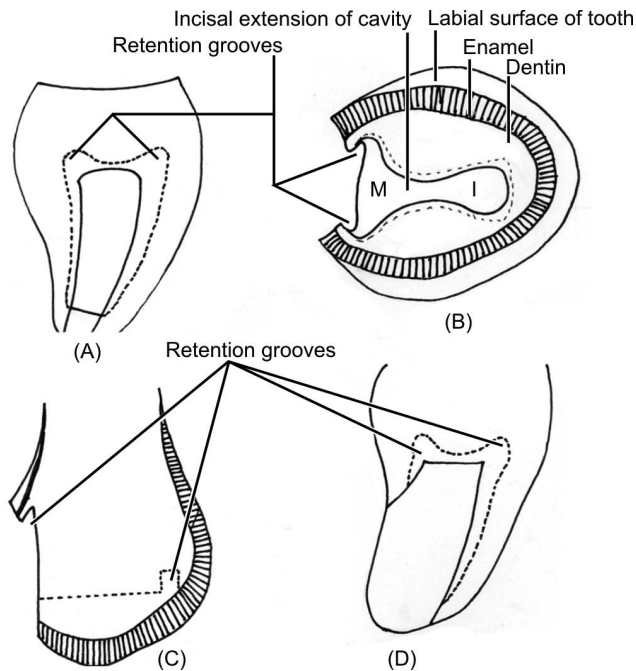
both are united through on isthmus on the lingual surface (Fig. 8.43).

- D. Class IV division 4 cavity—These are class IV cavities on both the incisoproximal angles and are united through the isthmus on lingual surface (Fig. 8.44).

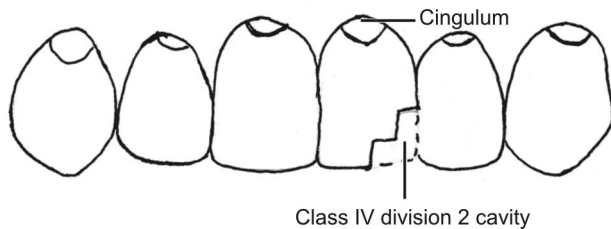
## Class V

Class V cavity are the cavities involving only cervical one-third of buccal and lingual surfaces of all the teeth (Figs 8.45 to 8.50).

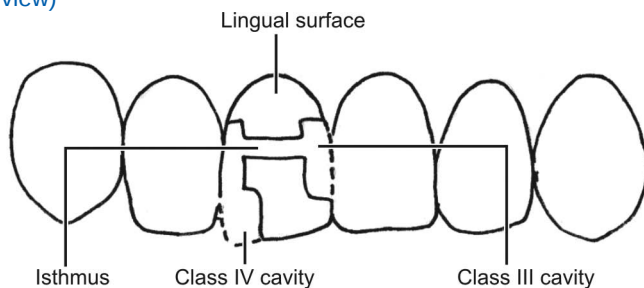
- A. Class V division 1 cavity—These are the cavities on the cervical one-third of buccal surface of posterior teeth (Figs 8.45 and 8.47).
- B. Class V division 2 cavity—These are the cavities only on the cervical one-third of lingual surface of the posterior teeth (Fig. 8.48).



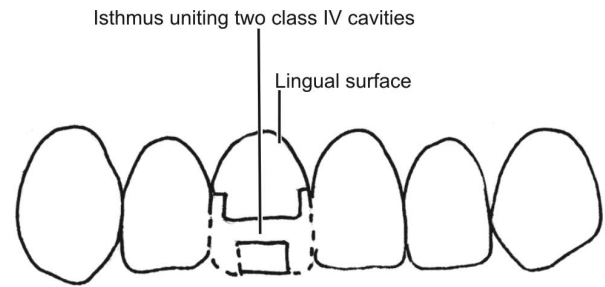
**Fig. 8.41:** Mesioincisal class IV division 1 cavity in maxillary canine continuous line showing cavosurface angle and broken line showing pulpal wall or pulpoaxial angle. (A) Mesial view (B) Incisal view of preparation (C) Labial view of preparation (D) Mesial view of preparation involving lingual surface also



**Fig. 8.42:** Class IV division 2 distoincisal angle cavity involving only distoincisal angle in left maxillary central incisor (lingual view)



**Fig. 8.43:** Class IV division 3 involving only class IV cavity on one proximoincisal angle and class III cavity on another proximal side and both are united through an isthmus on the lingual surface in right central incisor (lingual view)



**Fig. 8.44:** Class IV division 4 cavity – The cavity consisting of class IV cavities on both proximoincisal angles of the right central incisor (lingual view). Both the cavities are united through an isthmus on lingual surface

- C. Class V division 3 cavity—These are the cavities on the cervical one third of facial surface of the anterior teeth (Fig. 8.49).
- D. Class V division 4 cavity—These are the cavities only on the cervical one-third of lingual surface not involving lingual pit or any other surface of the anterior teeth (Fig. 8.50).

### Class VI

Class VI cavities are the cavities on incisal edges and cusp tips without involving any other pit, fissure, surface and angle of the tooth (Figs 8.51 and 8.52).

Class VI division I cavity—These are the cavities only on incisal edges of incisors and cusp tips of canines not involving any other pit, fissure, surface and angle of the tooth (Fig. 8.51).

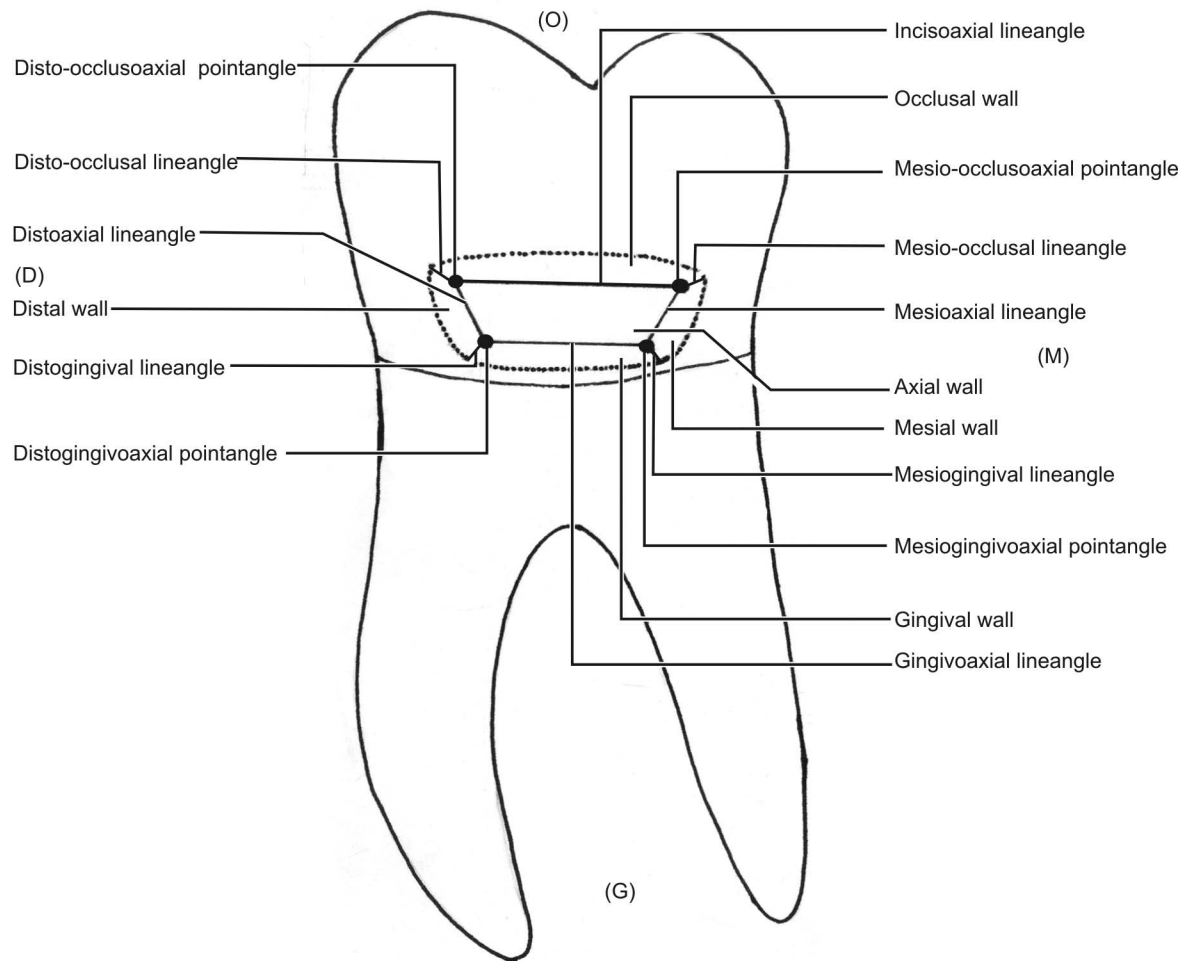
Class VI division 2 cavity—These are the cavities only on cusp tips of the posterior teeth not involving any other pit, fissure, surface, and angle of the tooth (Figs 8.52A and B).

### Class VII

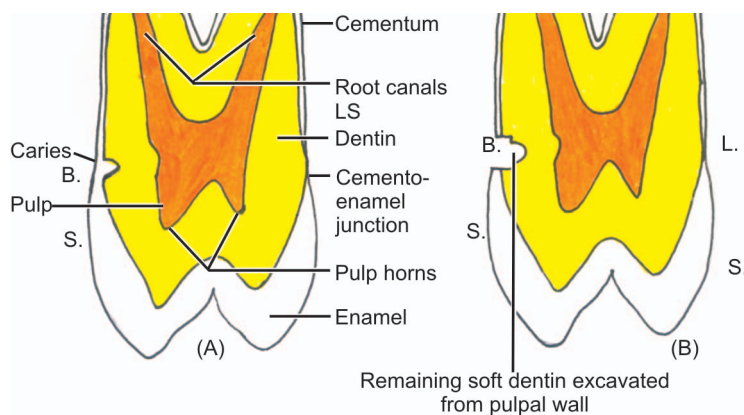
Class VII cavities are the cavities only on the labial surface of anterior teeth in the region of incisal third (not involving incisal edge) and middle third of labial surface without involving any other surface, angle, pit or fissure of anterior teeth (Fig. 8.53).

Class VII division 1 cavities are the cavities only confined on the incisal third of labial surface not involving incisal edge without involving any other part of the labial surface, or surface, angle, pit or fissure (Fig. 8.53).

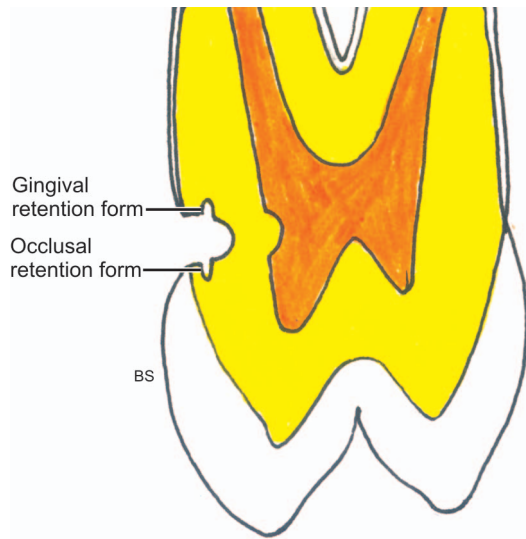
Class VII division 2 cavities are the cavities only confined on the middle third of labial surface of anterior



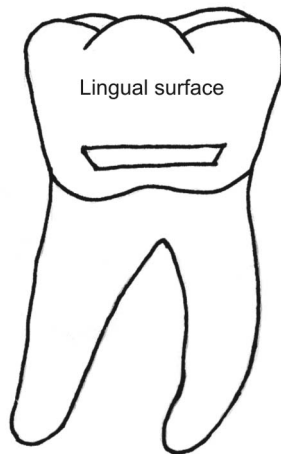
**Fig. 8.45:** Walls and angles in a class V division 1 cavity involving only cervical third on buccal surface in mandibular molar. Continuous line shows cavosurface angle and broken line shows pulpal wall (O)= Occlusal side (D)= Distal side (G)= Gingival side (M) = Mesial side (buccal view)



**Fig. 8.46:** Class V division 1 cavity (buccolingual vertical section) Initial tooth preparation with 90° cavosurface margins and axial wall depth is increased to make it caries free (BS-Buccal surface) (LS-Lingual surface) (A) Carious lesion on cemento-enamel junction (B). Cavity prepared and remaining soft dentin excavated from pulpal wall (buccolingual section)



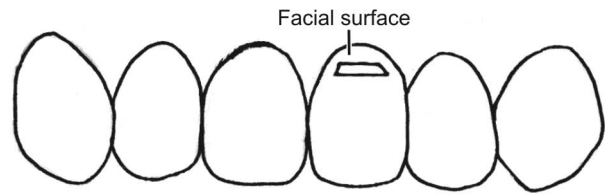
**Fig. 8.47:** Class V division 1 cavity with occlusal and gingival retention forms (grooves) (buccolingual vertical section) (BS = Buccal surface), (LS = Lingual surface)



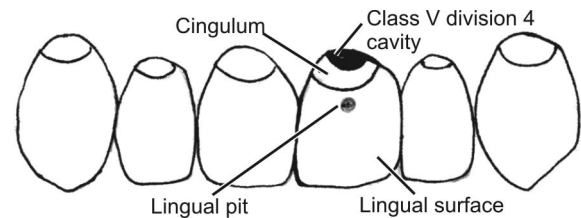
**Fig. 8.48:** Class V division 2 cavity involving only cervical one third on lingual surface of mandibular molar (lingual view)

teeth not involving incisal edge without involving any other part of the labial surface, or surface, angle, pit or fissure (Fig. 8.53).

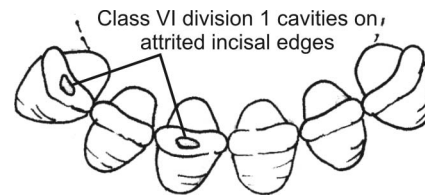
Class VII division 3 cavities—These are the cavities involving incisal third and also middle third of labial surface of anterior teeth not involving incisal edge, without involving any other part of the labial surface, angle, pit or fissure (Fig. 8.53).



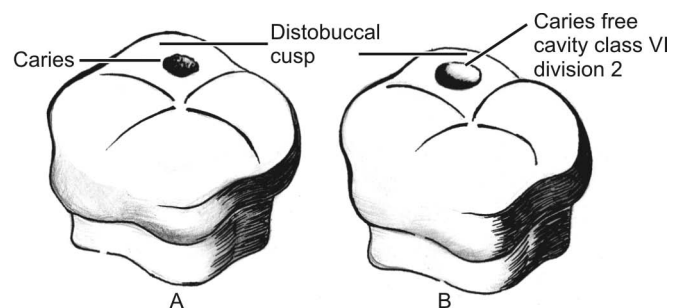
**Fig. 8.49:** Class V division 3 cavity involving only cervical third on the facial surface of maxillary left central incisor (facial view)



**Fig. 8.50:** Class V division 4 cavity involving only cervical one third on lingual surface and not lingual pit or any other surface of maxillary left central incisor (lingual view)



**Fig. 8.51:** Class VI division 1 cavities in mandibular right central incisor and canine attrited teeth involving only incisal edge of right mandibular central incisor and cusp tip of the canine (incisal view)

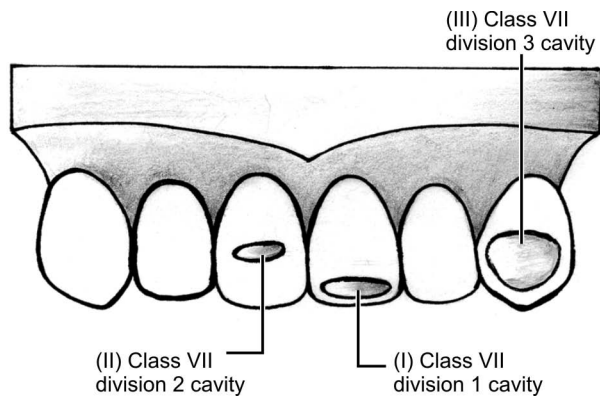


**Fig. 8.52:** Class VI division 2 cavity preparation involving only cusp tip of mandibular molar (A) Caries on distobuccal cusp (B) Cavity preparation before restoration

## TYPES OF CAVITIES

Each class, division, subdivision of cavity according to the proximity to the pulp is further divided into four types (A) to (D) (Fig. 8.54)





**Fig. 8.53:** Class VII cavity on labial surface of anterior teeth (I) class VII division 1 cavity in maxillary left central incisor. (II) class VII division 2 cavity on right maxillary central incisor. (III) class VII division 3 in left maxillary canine (labial view)

The four types are as follows:

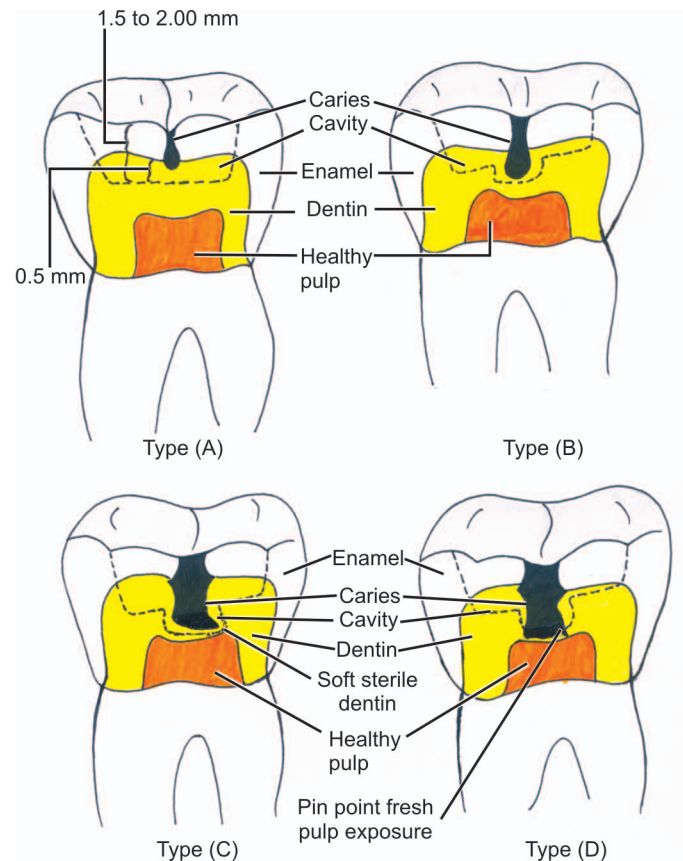
**Type (A):** A prepared cavity that extends to a minimum depth in dentin, but is adequate from a mechanical and biologic standpoint. Maximum possible thickness of the dentin remains intact (Fig. 8.54A).

**Type (B):** A prepared cavity that extends into the dentin beyond the minimal depth [and deeper than type (A)] required by the mechanical and biological factors. There is no serious encroachment near the pulp. A sufficient thickness of dentin remains to protect the pulp (Fig. 8.54B).

**Type (C):** A prepared cavity that extends into the dentin to an extent [deeper than type (B)] that an indirect pulp capping is indicated (Fig. 8.54C).

**Type (D):** A prepared cavity that extends into the dentin to such an extent that a recent pinpoint pulp exposure is actually observed and direct pulp capping is indicated (Fig. 8.54D).

This classification is simple and comprehensive in all respects and is definitely helpful and an excellent guide in the treatment planning. The class of the cavity can be communicated in print and by computer. After number of tooth as per FDI system, mention the class of the cavity, then division of the cavity and then subdivision of the cavity and then the type of the cavity. By indicating class, division, subdivision and type the complete and comprehensive picture of the cavity along with its relation to the pulp and the probable line of treatment and prognosis are crystal clear. By this classification teaching, research, communication and



**Fig. 8.54:** Classification types of prepared cavity according to the proximity to the pulp (Mesiodistal sections)

**Type (A)** Cavity caries (in black color) with minimum depth in dentin leaving maximum possible thickness of dentin.

**Type (B)** Cavity with a sufficient thickness of dentin to protect the pulp.

**Type (C)** Cavity where indirect pulp capping is indicated.

**Type (D)** Cavity where direct pulp capping is indicated. In black color is the extension of the caries/cavity. Broken line shows extension of the cavity

record keeping all are very easy and clear. All the classes, divisions, subdivision and types have definite and standard line of treatments. Hence, it is the most useful classification, which gives correct blue print and status of the prepared cavity in the tooth, line of treatment and the prognosis.

## GENERAL CONSIDERATIONS IN CAVITY (TOOTH PREPARATION) DESIGN

The design of the cavity should be in structural harmony with tooth tissue. The radiographs help in designing a



## 88 Textbook of Operative Dentistry

two-dimensional estimate of the extent of caries as well as anatomy of the enamel, dentin and pulp. The depth of wall, undercuts and flare of design are based upon the knowledge of tooth tissue and restorative materials. The estimation of the size of carious lesion is also important to remove the caries and protect the pulp and is best assumed by different views of radiographs. The cavity design must be related to tooth form and its dimensions to resist the functional stress.

The selection of rotary instrument should be related to the cavity design with most cutting efficiency and without any or least trauma to the soft tissues. The cavity preparation such as penetration, extension, excavation or refinement will require further selection of instrument. The sharp and concentric instrument of proper shape and size with cutting efficiency, sharp and concentric instruments are best suited for the purpose. The pulpal damage can be prevented by these measures. Temperature increases with dull instruments or lack of coolant to cause injury to the soft tissue like pulp, which may develop sensitivity. The higher rotational speed available these days provides excellent cutting efficiency. In high speed instruments, heat generation has to be inhibited by continuous spray of coolant like water and air to prevent the damage to the pulp. Premedication for control of excessive salivation may contribute to clear field of operation. The use of caustic or irritating drugs on freshly cut dentin should be avoided. The isolation of operative field by use of a rubber dam, cotton rolls, saliva ejector, and other evacuating instruments should give a better result of cavity design.

### FUNDAMENTAL PROCEDURES IN CAVITY (TOOTH) PREPARATION

The cavity preparation is accomplished through a systemic procedure based on the mechanical and physical principles. The preparation of cavity should be furnished in an orderly sequence, but under certain conditions, such as extensive caries that involve the pulp, this sequence may change. GV Black suggested the order of procedure to encourage a systemic approach to a restorative dental treatment. Recently, following Black's modified steps based on the improved cutting devices and properties of the materials are observed. They are divided mainly into two stages.

#### Stage I

Initial tooth (CAVITY) preparation steps

1. Outline form and initial depth.
2. Primary resistance form.
3. Primary retention form.
4. Convenience form.

#### Stage II

##### Final Tooth (CAVITY) Preparation Steps

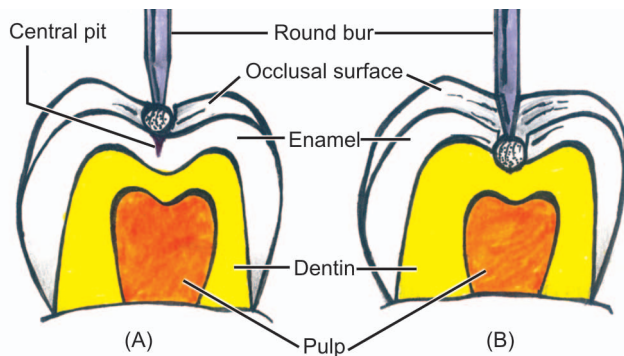
5. Removal of any remaining enamel pit or fissure, infected dentin and/or old restorative material, if indicated.
  6. Pulp protection, if indicated.
  7. Secondary (additional) resistance and retention form.
  8. Procedures for finishing the external walls of the tooth preparation.
  9. Final procedures: cleaning, inspecting and sealing.
- Under special conditions these sequences are changed.

#### Outline Form and Initial Depth

The outline form means extending the cavity margins to the place they will occupy in the final cavity preparation. This defines the external boundaries of the prepared cavities. Initial depth of the cavity is also ascertained by estimating the depth of the cavity. The following factors guide the outline form and initial depth form.

- A. Extension of carious lesion.
- B. Proximity of the lesion to other deep structural surface defects.
- C. The esthetic consideration.
- D. The relationship of approximating and opposing teeth.
- E. Susceptibility to caries.
- F. The restorative material to be used.

The outline form includes the external outline form and internal outline form. First establish the external outline form to extend all margins into sound tooth tissue, preparing an initial depth of 0.2 to 0.8 mm in the dentin towards the pulp (Fig. 8.55). Before any mechanical alteration of tooth, outline must be visualized to access the proposed cavity preparation. In small or localized carious lesion, cavity design should



**Fig. 8.55:** Angle of round bur for pit penetration (faciolingual section) (A) Central pit penetration (B) After penetration of Enamel bur tip has reached dentin

be very conservative in dimensions whereas in area where enamel is missing or affected, the outline form may be more extensive. The margins of preparation not only extend into sound tooth tissue but also involve adjacent deep pits and fissures in prepared cavity. Black referred to it as 'extension for prevention'. The external outline form is a matter of clinical judgment based on variety of oral conditions.

Factors guiding the outline form and depth in occlusal cavities.

- A. Remove all caries and cavity margins are extended to healthy tooth structure.
- B. All unsupported enamel rods are removed from stress bearing areas.
- C. Extension for prevention- All deep pits and fissures within 0.5 mm of the cavity should be included and if the thickness of wall between two cavities is less than 0.5 mm, both the cavities are united into one cavity, otherwise prepared as separate cavities.
- D. Avoid ending cavity margins in high stress areas like cusp tip and crest of the ridges.
- E. Margins are extended so as to facilitate all procedures.
- F. Due to esthetic reasons cavity should be made as conservatively as possible.

The pits, fissures, or other developmental irregularities may exist along with margins. The deep pit and fissure defects less than 0.5 mm apart should be included within the outline form. The external outline form should consist of smooth curves, straight lines and rounded angles. Smooth curves are most often seen on occlusal surface. Sharp or irregular projection of tooth

tissue within outline form will not only tend to be fragile but good adaptation of restorative material to cavity walls and margins will be difficult. All cavosurface margins are extended to include tooth tissue affected by caries process. The enamel that is unsupported by dentin as well as the demineralized enamel should be removed.

From the inner dimensions of the cavity, unnecessary loss of tooth tissue should be avoided. The relationship of occlusal walls from cavosurface angle to the pulpal floor is a part of internal outline form. The enamel is brittle and dentin is elastic. The pulpal floor in enamel should be avoided. The cavity depth must be at least 1.5 to 2.0 mm vertical from the cavosurface margin to the pulpal wall and should be, at least 0.2 to 0.5 mm in dentin to provide adequate strength to resist fracture due to occlusal forces (Fig. 8.54 Type A).

### Outline of Proximal Cavities

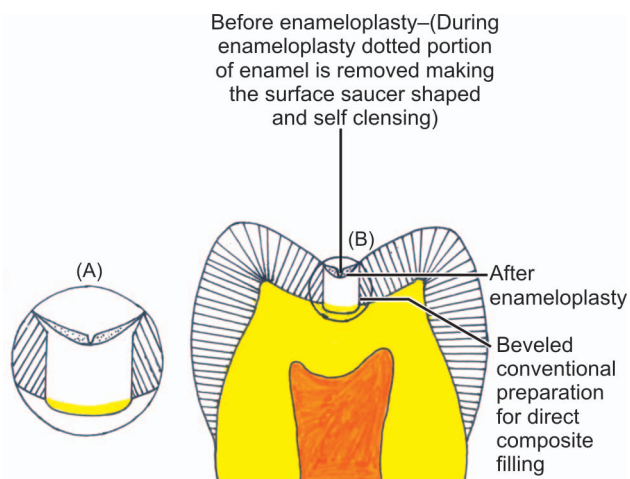
Outline of proximal cavities is controlled by the following factors.

- a. Extent of the caries on the proximal side.
- b. Dimensions of the contact area in the carious tooth.
- c. Caries susceptibility of the patient.
- d. If nonfluoride releasing restorative material is to be used then the cavity margins should be in a self cleaning area.
- e. Age of the patient.
- f. Position of gingiva and chances of future recession.
- g. Masticatory forces likely to fall on restorative material.
- h. Conservative proximal box is made because of esthetic reasons.

For establishing the outline form for proximal cavities extend the cavity until sound tooth structure is reached. All unsupported enamel rods are removed, extending the margins to allow sufficient access for restoration. In class III preparation, position of incisal margins is in the area of contact, especially if esthetic restorative material is used or when incisal embrasure is not large to allow incisal extension out of contact area. An incisal margin of sound enamel in contact area should not be extended incisally. In the gingival portion of facial to lingual surface class V cavities are governed by the extent of caries, except pulpally. Therefore, extension mesially, gingivally, distally and occlusally is limited when sound tooth structure may be reached. The minimum axial wall depth is 0.2 to 0.5 mm extension into dentin.

**ENAMELOPLASTY**

Enameloplasty is the judicious removal of sharp and irregular enamel margins of the enamel surface by 'rounding' or 'saucering' it and converting it into a smooth-based groove or pit which may be easily cleaned and allow conservative placement of margins. The operator must be selective in the choice of area in which the enameloplasty has to be performed. The enameloplasty does not extend the outline form. The use of enameloplasty often confines the cavity preparation to one surface and a smooth union of the tooth surface and restorative material. Some workers have reported the use of LASER for enameloplasty. LASER has been reported to obliterate the deep pits and fissures of enamel (Fig. 8.56).



**Fig. 8.56:** Enameloplasty and Bevelled conventional design for class I cavity for direct composite filling (faciolingual section) (A) is the magnified view of encircled portion of (B)

Outline form for cervical/root/ gingival cavities on Buccal and lingual surfaces of class V cavities.

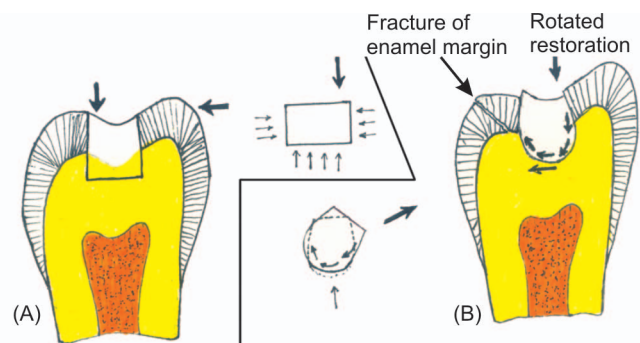
The following factors govern the cervical/gingival/root/ outline of the buccal and lingual cavities.

1. Size of the lesion guides the cervical outline of the cavity.
2. Restorative material—Selection of restorative material affects the shape of the cavity. Different shapes of the cavities are prepared for different restorative materials.
3. Age—In younger patients cavity margin is kept in gingival sulcus, in older patients having gingival recession the cavity margin is kept supragingivally.

4. Contour of the buccal/lingual surfaces affect design of the cervical cavities.
5. Oral hygiene, forces of mastication, pattern of occlusal contacts also affect the design of cervical cavity.

**Primary Resistance Form**

Primary resistance form is that shape and configuration of cavity walls to enable a placement of restorative material, so that both the tooth and restoration best withstand the stresses of masticatory forces without fracture. Masticatory stress pattern for every tooth is different. This stress pattern must be recognized for successful cavity preparation. The masticatory forces are delivered basically in the long axis of the tooth. For protection against oblique forces secondary and additional resistance and retention forms are followed which have been described later (Fig. 8.57).



**Fig. 8.57:** Resistance form to resist the masticatory forces and the dislodgement of restoration (faciolingual vertical sections) (A). Flat pulpal floor prevents the rotation and dislodgement. (B). Rotated restoration with fractured enamel margin, rounded pulpal floor does not resist rotational dislodgement of restoration causing fracture of enamel margin

For obtaining the resistance form the followings must be followed.

- (A) Make a box-shaped cavity.
- (B) Establish a flat floor, which helps the tooth to resist occlusal masticatory forces without any displacement.
- (C) Provide adequate thickness of restorative material depending on its respective compressive and tensile strengths to prevent the fracture of both the remaining tooth structure and restoration. The minimal occlusal thickness for high copper amalgam for appropriate resistance to fracture under average masticatory force is 1.5 mm. The resistance form in proximoincisor preparation (class IV)

recognizes the faciolingual narrowness of anterior teeth, to obtain the resistance form. (D) Restrict the extension of external walls to allow strong ridge areas with sufficient dentin support. (E) Inclusion of weakened tooth structure – This must be done to avoid future fracture under masticatory forces which may result in failure of the restoration. (F) Slight rounding of internal line angle to reduce the stress in tooth structure to increase the resistance to fracture. (G) The next principle is capping of cusp in obtaining resistance form during cavity preparation. The amount of remaining tooth structure also affects the need and type of resistance form. The type of restorative material also dictates the resistance form. High copper amalgam requires minimal thickness of 1.5 mm, cast metal requires less thickness of 1.0 mm to resist fracture, porcelain requires a minimum thickness of 2.0 mm to resist fracture. The composite restorations and glass ionomer restorations are more dependent on occlusal wear potential of restorative area and usually require thickness of more than 2.5 mm.

### Primary Retention Form

Primary retention form is the form, shape and configuration of the prepared cavity that resists the displacement or removal of restoration from the cavity under all types of tilting and tipping masticatory forces. Black stated that in most cavities, the retention form is made by opposing walls which are strictly parallel or having very slight undercut in dentin. When two opposite walls slightly converge (for amalgam) or slightly diverge (for castings) occlusally the restoration will be retained firmly. Occasionally resistance and retention forms are obtained by same cutting procedures, hence they are sometimes described together, but are separately understood.

The retention form is also affected by the type of the restorative material used. The common factors are as follows.

1. Total surface area of the restoration exposed to the masticatory forces.
2. The severity of the masticatory load falling on the restoration.
3. Thickness of the restoration.
4. The amount of remaining dentin.

### A. Amalgam

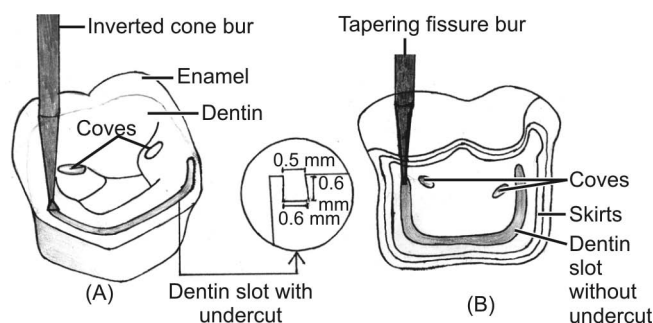
Retention is increased in amalgam restoration by the following.

- a. Converging (about 2 to 5%) the dentinal walls towards the tooth surface.
- b. Giving slight undercut in dentin near the pulpal wall (Fig. 8.58A).
- c. Conserving the marginal ridges.

### B. Castings

Retention is increased in cast restorations by the following:

- a. Parallelism of the walls—In deeper cavities slight divergence occlusally of two to five degrees is allowed to facilitate the withdrawal of the wax pattern. Two degrees of divergence in dentin and five degree of divergence in enamel is ideal.
- b. To prevent tilting of restoration in all types of class II cavities the occlusal extension must be sufficient even if there is no occlusal caries.
- c. Secondary retention in the form of coves, skirts and dentin slot without undercut (Fig. 8.58B).
- d. To prevent tipping movements in class I compound (class I division 3,4 and 5) and all types of class II, specially in MOD (class II division 5) cavities, reverse bevel is given.



**Figs 8.58A and B:** Occlusal views of coves, dentin slots and skirts (A) Coves and dentin slot with undercut for plastic restorative materials like amalgam (B) Coves, skirts and dentin slot without undercut for cast restorations

### C. Composites

In composites retention is increased by micromechanical bonding between the etched and primed prepared tooth



## 92 Textbook of Operative Dentistry

structure and the material. Depending on the cavity surface area, bond strength upto 47 MPa can be achieved.

### D. Direct Gold

Elasticity of dentin and starting point in dentin provide retention in direct gold fillings by proper condensation.

### Convenience Form

The convenience form is that form which facilitates and provides sufficient visibility, accessibility and ease of operation in preparing and restoring the tooth. Occasionally to obtain this form extension of distal, mesial, facial or lingual walls to gain sufficient access to the deeper portion of the preparation may be required. The cavosurface margin of the preparation should be related to the restorative material selected for the purpose of convenience to marginal adaptation.

This step is most important in class II, class III, and class IV cavities.

In class II division 3, 4 and 5 (MOD) preparations access is made through occlusal surface. In class III, usually through lingual surface, in class IV, through incisal edge. In class I, V, VI and VII the visibility and accessibility is direct and good. For Class II Tunnel preparation the proximal caries in posterior teeth is approached through a tunnel starting from the occlusal surface and ending on caries lesion on the proximal surface without cutting the marginal ridge [Figs 8.59A (a) and (b)].

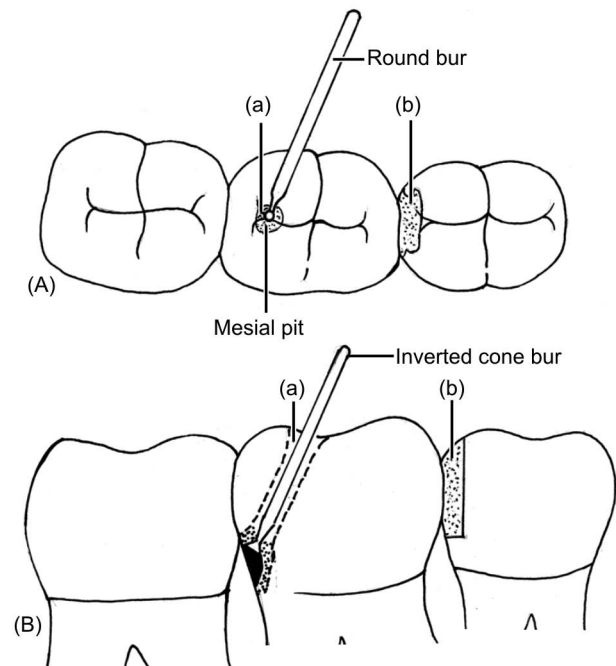
### FINAL STAGES OF TOOTH PREPARATION

After initial stages of the preparation, the cavity should be carefully examined. In teeth having initial caries after initial stages of tooth preparation the cavity is ready for filling for materials like composite, GIC, porcelain and amalgam requiring conservative preparation.

Occasionally additional steps (nos. 5 to 9) are required for final tooth preparation which are as follows.

### Removal of any Remaining Enamel Pit or Fissure, Infected Dentin and/or Old Restorative Material, if Indicated

In this besides removal of the remaining caries the old restorative material and adjacent deep pit and fissure, if indicated, are also removed and involved in the cavity. After the establishment of external and internal outline



**Fig. 8.59:** Tunnel (a) and Box only (b) preparation (A) Occlusal view of (a) Tunnel (Furrow) class II Preparation on mesial side in second mandibular molar. Caries is approached with a small round bur from the mesial pit on the occlusal surface. (b) Amalgam Box only proximal (class II) cavity preparation on mesial side of third molar. (B) Buccal or lingual view of the (a) Final shape to the tunnel preparation (shown with broken lines) is given by a small inverted cone bur removing all carious and soft dentin. On mesial sides black area is carious dentin and dotted area is soft dentin which are removed. (b) Amalgam Box only proximal class II cavity preparation on mesial side of the third molar (dotted area)

form, any remaining carious tooth structure or defective restorative material left in tooth may be removed completely with the protection of pulp. Infected and discolored dentin must be removed even if it leads to exposure of pulp which is treated accordingly. A small carious lesion may be completely eliminated by a conservative cavity preparation. The pulpal and axial wall should be established as initial cavity preparation and if a small amount of carious lesion remains, only this lesion should be removed, leaving concave, rounded area in the wall. In the large cavities with soft caries, the removal of carious dentin is done early in initial cavity preparation. The condition of both pulp and remaining tooth structure has definite adaptation of the restoration placed and for this region, it is more convenient to remove the extensive caries early in cavity preparation



to provide better opportunity to specific needs of retention and resistance form. The establishment of outline, resistance, retention and convenience form does not necessarily imply the order of procedure. It only suggests that this order is preferred for the efficient and effective operation.

### **Pulp Protection, if Indicated**

Pulp protection is a very important step in adapting the preparation for final restoration although theoretically it is not a step of cavity preparation. The bases and the liners are used to protect the pulp or to help pulpal recovery or both. When thickness of the remaining pulpal dentin is less pulpal injury is caused by the following:

1. Heat generation: Heat produced by high speed burs with less effective coolants may result in pulpitis, pulp abscess and pulp necrosis.
2. Cutting dentinal odontoblastic fibrils when exposed to irritating materials may result in degeneration of the affected odontoblasts. This may result in dead tract and pulpitis.
3. Restorative materials: Some restorative materials, produce exothermic heat during setting reaction or have some ingredients which may irritate the pulp.
4. Good thermal conductivity of some restorative materials may irritate the pulp.
5. Galvanic currents due to fillings of dissimilar metals or alloys in the same oral cavity.
6. Excessive masticatory forces transmitted through restorative materials to the dentin may irritate the pulp.
7. The ingress of microorganisms and their noxious products through microleakage and dentinal tubules irritate the pulp. Hence all microleakage and dentinal tubules must be sealed properly with calcium hydroxide, dentin bonding agents and resin modified glass ionomer liner over the calcium hydroxide to be effective.

If the thickness of the remaining dentin over the pulp is less than 2 mm the pulp protection must be done using liners, varnishes and bases depending upon the amount of dentin left and the restorative material to be used.

### **Liners and Varnishes**

Liners and varnishes are volatile resin or aqueous suspensions and dispersions of calcium hydroxide or

zinc oxide which can be applied to a tooth in relatively thinner films and have desired pulpal response. They are used where cavity depth is shallow and pulpal wall is thinner than 2 mm. They provide the following:

- a. A barrier to protect remaining dentin and pulp
- b. Provide galvanic and thermal insulation.

Under the composites and glass ionomer cements cavity liners and varnishes are not used.

### **Bases**

Bases are the cements used on pulpal and axial (internal) walls in thickness of about 0.5 to 2 mm beneath the permanent restorations. They provide thermal, galvanic, chemical and mechanical protection to the pulp. Commonly used base materials are zinc phosphate cements, glass ionomers, polycarboxylate cements, zinc oxide eugenol, and calcium hydroxide cement.

In deep caries where the pulpal floor is near the pulp or very near to the pulpal exposure, a calcium hydroxide or MTA (Mineral Trioxide Aggregate) base is given below the usual cement. Calcium hydroxide and MTA stimulate the formation of reparative dentin, when it is in contact or near the pulpal tissue. There may be microscopic exposures after very deep excavations. Hence in deep cavities liners and bases should be applied very lightly without pressure.

### **Secondary (Additional) Resistance and Retention Forms**

Occasionally inspite of providing all standard retention forms and also modifications according to various restorative materials, sufficient retention is not obtained. For such cases additional mechanical resistance and retention forms are adopted which are as follows.

### **Grooves**

Wherever bulk of dentin permits, grooves are prepared without undermining the adjacent enamel. Grooves are specially useful for cast restorations. These are mostly prepared in the walls of the proximal surfaces at the axiobuccal and axiolingual line angles and are kept parallel to the line of withdrawal of the wax pattern. More than one groove per wall should be avoided as they may weaken the wall. The retentive grooves can also be prepared in all types of crown preparations. All grooves must be in one direction and plane having at least 0.5 mm dentin around each groove.

## **94** *Textbook of Operative Dentistry*

### **Slots or Internal Boxes**

These are 1.0 to 1.5 mm deep box like grooves prepared in dentin to increase the surface area. These are prepared in occlusal box, buccoaxial, linguoaxial and gingival walls. These are box shaped having four walls and can be prepared for all the restorative materials. For cast restorations these are prepared by tapered fissure bur to avoid undercuts and for plastic restorative materials like amalgam these are prepared by inverted cone bur to create slight undercuts in dentin (Fig. 8.58).

### **Locks**

These are prepared mostly for amalgam class II restoration in the proximal or occlusal box of class II cavity. These are smaller in size (0.25 to 0.5 mm wide and 0.5 to 1.0 mm deep in dentin).

### **Pins**

Various types of pins of various shapes and sizes suitable for different situations are available to provide additional retention. They are used in all types of restorations like amalgam, composite and cast restorations. In 1980 Shavell recommended amalgapin technic for complex amalgam restorations.

### **Skirts**

For additional retention in cast restorations skirts are prepared, to increase the total surface area of the preparation. Cuspal coverage is also a type of skirt preparation. Skirts can be prepared on one to all four sides of the preparation depending upon the required retention. The skirts extend the surface area (Fig. 8.58).

The inversely tapered walls of proximal box provide retention form to resist the tensile forces. The retention or resistance form almost require performing the same cutting procedure, and mostly are discussed together, and rarely separately. The proximal retention is to resist the horizontal component of masticatory forces to unseat the proximal box from the axial wall. The buccal and lingual proximal walls require divergence to produce the sound enamel margin and they are almost nonretentive. Grooves within the proximal dentin wall provide proximal retention. In inlay and onlay preparations for cast metal restoration, the dentin of the side walls diverges outwards by 2 degrees and enamel by 5 degrees. The resistance and retention form are peculiar in that they differ from one restorative

material to another, in the manner of restoration and fabrication either directly or indirectly.

### **Coves**

These are small conical depressions in healthy dentin to provide additional retention (Fig. 8.58).

### **Steps and Amalgampins**

These provide additional resistance and retention forms required for larger cavities. Steps and Amalgampins are used for larger amalgam fillings.

### **Beveled Enamel Margins**

Bevelling of the cavity margins increases the surface area thereby the retention in cast gold/metal and composite restorations.

### **Enamel Wall Etching**

Etching results in microscopic roughness, which increases the surface area and provides micro-mechanical retention.

### **Dentin Conditioning (Etching and Priming)**

Etching and priming of the dentin surface done in some restorative materials increases the retention.

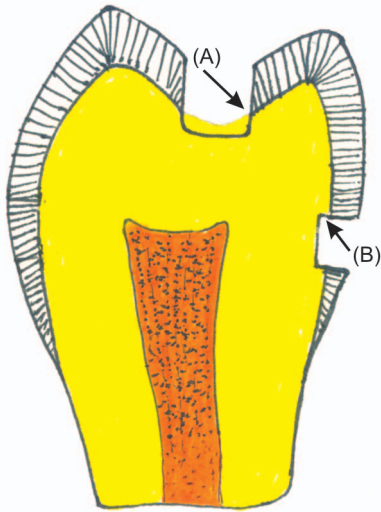
### **Adhesive Luting Cements**

Adhesive luting cements increase the retention of indirect restorations.

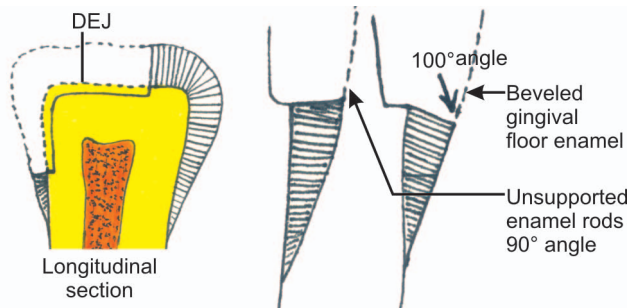
### **Procedures for Finishing the External Walls of the Tooth Preparation**

Finishing of the enamel margins should be done in case of all restorative materials. It is the further development of specific cavosurface design and smoothness that produces the maximum adaptation of restoration to the walls and the margins and maximum effectiveness of restoration. The finishing of the cavity walls is done for the following (a) to create the better marginal seal between restorative material and tooth structure (b) to provide maximum strength to both tooth structure and restorative material (c) for strong location of the margins (d) for proper degree of smoothness of the margins (Figs 8.60 and 8.61).

The design of cavosurface angle is dependent on restorative material being used. In amalgam restoration, cavosurface angle of 90 degrees provides maximum



**Fig. 8.60:** All enamel walls must have support of sound dentin  
(A) All shortened enamel rods supported by sound dentin  
(B) Full length enamel rods supported by sound dentin. Buccolingual vertical section



**Fig. 8.61:** Finishing the unsupported gingival floor enamel on dentin and beveled by gingival margin trimmer to form 90 to 100° cavosurface angle. All enamel walls must be supported by sound dentin (vertical sections)

strength to tooth restoration. Beveling of external wall is done in materials such as cast gold alloys and not in composite restoration. It produces stronger enamel margin, as the marginal metal is more easily burnished and adapted. During finishing of the cavity walls and margins principles of paralleling the direction of enamel wall should be adhered. The finishing of cavity wall is guided by knowledge of enamel structure and careful

testing of the margins with hand instruments. The knowledge of enamel rods is necessary for proper finishing of the cavity margins. But end of the cavity margins are preferred in amalgam due to poor edge strength. To remove unsupported enamel rods near gingival margins it must be slightly beveled. A short bevel is given in cast gold restoration. An ultrashort bevel is given in case of gold foil. No beveling is done in case of composite resins and porcelain except very minor beveling may be done for the color matching in anterior teeth cavities only.

### Final Procedures; Cleaning, Inspecting and Sealing

The final cavity preparation includes the cleaning of cavity walls and margins from objects that may interfere with the proper adaptability and behavior of the restorative materials. The debridement or toilet of the cavity has following three objectives.

- Freeing of all cavity or preparation walls, floors and margins from enamel and dentin chips resulting from excavation and grinding. Mild detergents having very mild properties are used with cotton swabs for this purpose. Strong detergents and antiseptics and compressed air should not be used for this purpose.
- Drying the cavity/preparation walls, floors and margins before insertion of the restorative materials. The bonding agents used with composites for enamel bonding are hydrophobic and prefer dry enamel. The bonding agents used with composites for dentin bonding are hydrophilic and prefer wet dentin. For debridement air, water, dry cotton pellets and commercial cavity cleaners are used.
- Sterilization of cavity walls with very mild alcohol free disinfectant is done. Which ever debridement technic is used a microscopic layer of dentinal smear called 'smear layer' is always present on cut dentin. It can be eliminated with a 10 percent solution of EDTA or mild acids. Its removal is essential for chemically adhesive filling materials. This is also called 'conditioning' of the cavity preparation walls and floor. It is carried out for glass ionomer and composite restorations. During 'etching' the inorganic salts are partially removed to facilitate bonding. These tags help in mechanical union between the tooth and the filling material. The first

procedure includes complete removal of loose debris, drying the cavity and doing a final inspection of cavity. Most of the gross debris is removed during preparatory steps but fine debris remains on the cavity walls after all the cutting is completed. The procedure of cleaning the cavity is making it free from debris with warm water from the syringe and removing the visible moisture with very mild pressure air syringe. It is important that teeth are not dehydrated by overuse of air or hot air.

The disinfection of a cavity before inserting a restoration is the correct procedure. Mild disinfectant in cavities serves the purpose of disinfection.

### **Atraumatic Restorative Treatment (ART)**

With the development of (a) bonding (b) adhesive and (c) fluoride releasing restorative materials like glass ionomer cements, the concept of cavity and tooth preparation is undergoing revolutionary changes. In this the procedure 'retention' has not been given much importance. The details have been discussed in the chapter of Glass Ionomer Cements.

### **Additional Concepts in Cavity (Tooth) Preparation**

Several new tooth preparation and restorative techniques have been advocated. The operators must remember the fundamental requirements for a successful cavity preparation. The broad concept of cavity preparation must be observed. Applying specific restorative procedures, combined with operative skills with proper handling of the restorative material will result in successful treatment.

### **Bonded Amalgams**

New technique for amalgam restoration is used which bonds the amalgam material to tooth structure. Preparation of cavity is same as typical amalgam cavity preparation except the more weakened remaining tooth structure which is routinely removed may be retained. Next, the cavity walls are covered with specific adhesive lining material which bonds the restorative material and tooth structures. Details are given in chapter entitled "Complex Amalgam Restorations".

In consideration of the following developments, the conservative cavity preparation is recommended.  
(a) Anticariogenic properties of the restorative materials  
(b) Adhesive and bonding restorative materials

(c) Reduced susceptibility to caries (d) Improved oral hygiene devices, (e) Better oral hygiene sense and practices by the patients (f) Improved diagnostic devices and (g) tendency of the operator for conservative cutting of tooth structure. The minimum cutting of healthy tissues is recommended by most of the workers.

Tunnel cavity preparation and box only proximal cavity preparations are conservative efforts in this direction. The extension of the carious lesion is examined clinically and radiographically.

### **Box Only Proximal (Class II) Cavity Preparation**

Box proximal cavity preparation usually for amalgam can be made for posterior tooth in which only proximal surface requires restoration but occlusal surface is not carious and adjacent tooth is present and is healthy. In this a small proximal box is prepared and specific retention form is provided, but no occlusal step is included. Minimum occlusal surface is involved only to approach the caries. In this the marginal ridge is involved unlike tunnel preparation in which marginal ridge is undermined but not cut away and its occlusal surface remains intact [Figs 8.59A (a) and B (b)].

## **TUNNEL CAVITY PREPARATION AND RESTORATION**

Clinically and with the help of radiographs the carious lesion is located. When small carious lesion is present only on the proximal surface of posterior tooth and the adjacent tooth is present and is healthy and when caries susceptibility index is low, tunnel cavity preparation may be considered.

In the class II tunnel preparation the cutting of marginal ridge is avoided and the caries which is present only on the proximal surface of the posterior teeth is removed. To reach the caries a tunnel is prepared starting from occlusal surface undermining but preserving the marginal ridge. The preparation of tunnel is started from the occlusal pit of carious side on the occlusal surface with the help of a small round bur, after protecting the adjacent tooth with metal strip. The tunnel is directed approximately at about 45° angle towards the carious lesion. After approaching the lesion with round bur, then with tapering fissure bur the access is slightly widened. With the help of long shank sharp excavators and inverted cone burs, by moving their



cutting tip as far as possible in all directions, the caries is completely removed. It is confirmed with the help of RVG and radiographs [Figs 8.59A (a) and (b)].

After making the tooth caries free matrix band is properly adapted and wedge is placed so that matrix is tightly adapted to the tooth surface avoiding overhanging restoration, and injury to the underlying gingiva. Then the restorative material is condensed from the occlusal opening avoiding any void. After initial hardening of the restorative material the wedge is gently removed. Then the matrix band is gently removed without disturbing the restoration. The occlusion is checked and extra material if any is removed. The filling is finished and polished as usual.

### **Precautions**

It is almost a blind procedure, hence the cutting end of the bur should be precisely directed towards the center of carious lesion as seen in the radiograph and following precautions should be taken.

1. The angulation of the bur should be predetermined. It can be done by sticking of the three pieces of 2.0 cm long straight 25 gauge wire, each at slightly different angles, on the buccal surface of the affected tooth. The wires are fixed in such a way that as far as possible one end of the wire should cross the center of the caries lesion and other end should extend beyond the occlusal surface after passing through the occlusal pit of the side on which caries lesion is present, i.e the point from where the tunnel preparation is to be started. These wire pieces are fixed on the dried buccal surface of the affected tooth with the help of sticky wax and then a radiograph is taken with 1 mm square wire gauge mounted on X-ray film. The developed X-ray film should show (a) the affected tooth (b) the superimposed three wire pieces (c) caries lesion (d) 1 mm square wire gauge superimposed on all structures. By all these the correct angulation and distance between the center of the lesion and the occlusal pit of the affected side can be determined. The other simple method is to fill little zinc oxide eugenol paste as deep as possible on the occlusal pit of the affected side of the tooth and the carious lesion and take a radiograph on the one mm square gauge mounted X-ray film. The angulation between the lesion and the occlusal pit which will be visible on radiograph can

be measured. The bur is kept at the same angle to reach center of the lesion.

Note: For details of one mm square gauge mounted radiograph Figure 7.6 of chapter 7 on Clinical Diagnostic Procedures of 'Textbook of Endodontics with MCQs' by the authors may be referred.

2. After cutting upto dentino-enamel junction radiograph should be taken or RVG check should be done along with the bur present in the tunnel preparation to ascertain the correction of the angulation of the bur before proceeding further. The same should be repeated every time after proceeding 2 to 3 mm further towards the carious lesion till it is finally reached.
3. Constant angulation of the bur has to be maintained because the tunnel should be in a straight line to facilitate excavation of the caries and condensation of the restorative material.

After reaching center of the carious lesion, all carious dentin and enamel is removed with the help of small sized inverted cone bur and long shaft sharp spoon excavator. The complete removal of the carious lesion and all soft dentin is ensured clinically and with the help of the radiograph or RVG.

After complete removal of the carious lesion a stainless steel band with the help of matrix and wedge is adapted tightly to replace the missing proximal wall. Small increments of the filling material like amalgam are condensed from the occlusal surface to completely fill the cavity. The filling of the cavity is checked clinically and radiographically.

### **Advantages**

1. Maximum possible healthy tooth tissues are preserved and minimum healthy tooth tissues are removed.
2. Strength of the tooth and the proximal contour is maintained, as marginal ridge is not cut.
3. Usually caries start below the contact area, hence contact area is maintained unless it is also carious.
4. Chances of overhanging restoration are minimized as minimum area of the proximal surface is cut.
5. Minimum restorative material is used.
6. Time spent by the operator and patient is very much reduced, hence output is increased to almost four times.



**Disadvantages**

1. Limited indications. Only indicated in small lesions in teeth where life expectancy of teeth is not more than five years like deciduous teeth or slightly loose teeth of geriatric patients.
2. On proximal part it is almost a blind procedure as visibility is poor.
3. Marginal ridges although not cut, become weak.
4. Complete removal of caries lesion on proximal side is difficult. Chances are there that soft dentin on the proximal side is left out at the margins.
5. On proximal surface the marginal adaptation of restorative material may not be perfect.
6. Finishing of the proximal margins is difficult and may not be perfect.
7. The chances of marginal leakage and recurrent secondary caries at the margins of the proximal surface are more.

## FORCES ACTING ON RESTORATIONS DURING FUNCTIONAL AND PARAFUNCTIONAL MOVEMENTS

Different forces act on restorations during various functional and parafunctional movements of the mandible. They are not only vertical forces but also other types of forces. Tooth counteract these forces with the help of periodontal membrane and alveolar bone. On the flat surfaces that are perpendicular to the force of mastication, only vertical forces will act, while on the curved surfaces, other forces also act.

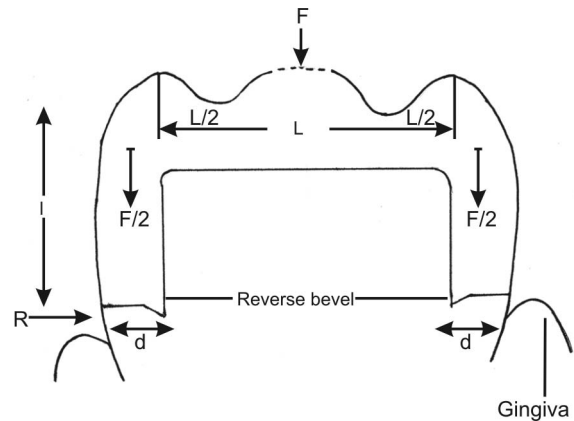
As the load is applied over the teeth, stresses are distributed (i) parallel to long axis (ii) perpendicular to long axis of teeth. DO and MO preparations are examples of cantilever beam.

In MOD cavity preparation, the force (F) is divided equally on both the sides. The mesio-distal length (L) is also divided into two. The moment of force at the midpoint is:

$$F/2 \times L/2 = FL/4$$

Moment of force = Force  $\times$  perpendicular distance

Thus in MOD preparations the length of axial walls should be kept equal on both the ends for having equal forces acting on both sides. The total retentive force (R) is equal to  $F \times L/l$  where 'l' is the depth of axial wall. In DO, MO and MOD preparations if depth of gingival wall (d) is considered, then R and d are in the same



**Fig. 8.62:** Dislodging forces in MOD restoration and their neutralization (Buccal or lingual view)

direction, hence their moment of force remains zero (Fig. 8.62).

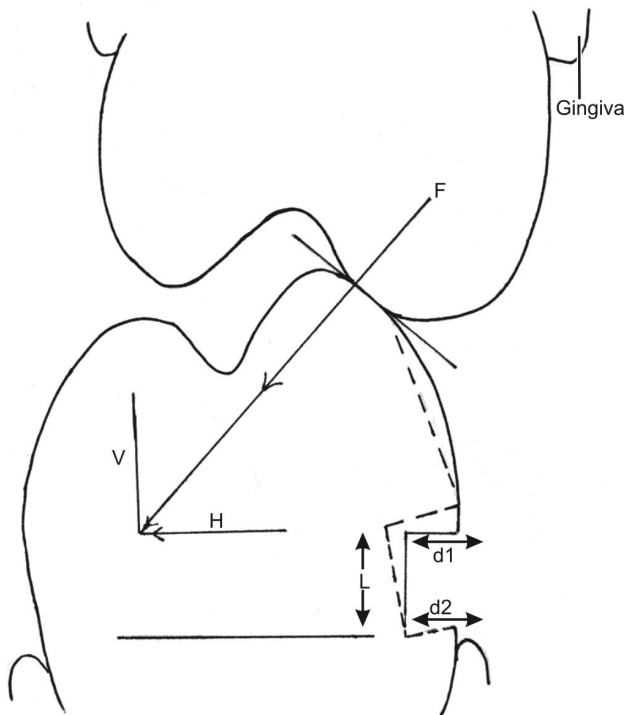
In class V cavities, certain forces act on the cervical region, which can destabilize the restoration. During functional occlusion, the transverse forces try to bend the tooth gingivo-occlusally, in case of cavities in cervical region, the deflective force is increased. If restorative materials are not adhesive in nature, a gap can be created at the cervical surface of the restoration on buccal side and occlusal surface on lingual side. In Figure 8.63, Force (F) is applied at inclined plane perpendicular to the tangent of the planes. The horizontal component (H) acts approximately at the center of the tooth. Vertical component (V) is constant. The deflection is mainly due to horizontal component which depends upon the height of axial wall (L) and the depth of the occlusal (d1) and cervical walls (d2) (Fig. 8.63).

## IMPACT AND DISTRIBUTION OF FORCES IN VARIOUS CLASSES OF RESTORATIONS

### [A] Class I and Class VI Restorations

In case of plastic materials like amalgam restorations the side walls converge occlusally and the pulpal floor is flat. In case if floor is not flat and is concave then the forces acting on the tooth will rotate the restoration on both the sides [Fig. 8.57 (B)].

In case of cast restorations the pulpal floor is flat and side walls are slightly diverging occlusally to prevent the rotation of restoration under the forces acting on it.



**Fig. 8.63:** Dislodging forces in cervical restoration and their neutralization (mesial or distal view)

### [B] Class II and Class IV Restorations

Stresses mostly act on marginal ridges in class II restorations. The axiopulpal line angle in both class II and IV restorations should be slightly rounded, to increase the strength of material by increasing the bulk at this line angle because of greater amount of forces which are acting on axiopulpal line angle. In MOD preparations, the length of axial walls should be kept as far as possible equal on the both sides for balancing the forces acting on it. In case of MO or DO cavity, gingival retention is obtained by making the gingival seat flat and rounding of the axiopulpal line angles is also done.

### [C] Class III Restorations

Only transverse forces have a role in rotation of these restorations, as these lesions are not in direct contact with the opposing teeth. Lingual lock in the dentin is given to approach the lesion from lingual side and to minimize the stresses.

### [D] Class V and Class VII Restorations

Transverse forces mainly act in the cervical region (Class V) and on labial middle and incisal thirds of anterior teeth (class VII restorations) which may rotate the restorations and a gap is evident on the cervical/occlusal/incisal walls of cavity. Thus a restorative material that is adhesive in nature should be used to prevent the rotation of restoration in case of class V and VII cavities.

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# 9

## Dental Materials

The knowledge of dental materials used in dental practice is very important for every dental surgeon. In operative dentistry, major aim of restorative materials is to restore the tooth structure which has been lost due to caries, surgically removed for treatment of carious lesions and lost because of attrition, abrasion, erosion and fracture. By restorative materials, tooth as far as possible is restored to ideal esthetics, form and function. In the dental material science, study of materials used in various branches of dentistry is done. In operative dentistry those materials are used for restoration which restore and maintain good health of the pulp and surrounding tissues.

For restoration of teeth, there are numerous materials. Every year improved materials are being added. These restorative materials can be classified according to (A) their lasting qualities, (B) their properties and (C) mode of use.

### CLASSIFICATION OF RESTORATIVE MATERIALS

- A. According to their lasting qualities
  - I. Temporary
    - 1. Zinc oxide-eugenol
    - 2. Zinc phosphate cement
    - 3. Silicate cement
    - 4. Self-curing acrylic resin
    - 5. Gutta-percha
  - II. Permanent
    - 1. Pure gold
    - 2. Cast metal alloy
    - 3. Amalgam
    - 4. Ceramics
- B. According to their working properties
  - I. Plastic restorative materials
    - 1. Amalgam
    - 2. Cements
    - 3. Resins
    - 4. Pure gold
    - 5. Ceramics

- II. Non-plastic restorative materials
  - 1. Cast gold alloys
  - 2. Castable dental ceramics
  - 3. Autocopy milling ceramics-CAD-CAM etc.
- C. According to mode of use of restorative materials
  - I. Directly used restorative materials
    - 1. Amalgam
    - 2. Cements, Bases
    - 3. Bonding agents
    - 4. Pit and fissure sealants
    - 5. Composites
    - 6. Glass ionomer cements
    - 7. Direct filling gold
    - 8. Direct filling ceramics
  - II. Indirectly used using restorative materials
    - 1. Cast metal restorative materials
    - 2. Indirect dental ceramic materials
    - 3. Metal ceramic materials
    - 4. CAD CAM/CEREC 2 and 3 system materials.

### AMALGAM

Amalgam is an alloy in which mercury occurs as a main constituent. It is the oldest and as per world sale record, still the most widely used restorative material than any other material used in operative dentistry, although its use has been banned in few countries.

Composition: Amalgam consists of amalgam alloy and mercury. Amalgam alloy is composed of silver-tin alloy with varying amounts of copper and small amount of zinc. Dental amalgam alloys are mainly of two types, low copper and high copper alloys (Table 9.1).

### Effects of Constituent Metals on the Properties of Amalgam

**Silver:** Most of the alloys contain 60 to 70 percent (by weight) of silver but in some of the special alloys its percentage may be 40 to 77 percent. It has the following effects on the properties of amalgam.

- a. Increases strength

**Table 9.1:** Approximate composition of few popular low and high copper amalgam alloys

|                     |                       | Percentage of elements by weight |          |          |        |           |        |
|---------------------|-----------------------|----------------------------------|----------|----------|--------|-----------|--------|
| Types of Alloys     | Particle Shape        | Silver                           | Tin      | Copper   | Zinc   | Palladium | Indium |
| 1. Low copper       | Lathecut or Spherical | 65 to 77                         | 25 to 28 | 2 to 6   | 0 to 2 | 0         | 0      |
| 2. High Copper      |                       |                                  |          |          |        |           |        |
| A. Admixed          | Lathecut              | 40 to 68                         | 25 to 30 | 9 to 30  | 0 to 2 | 0         | 0      |
|                     | Spherical             | 40 to 70                         | 0 to 30  | 20 to 30 | 0      | 0         | 0      |
| B. Unicompositional | Spherical             | 40 to 60                         | 22 to 30 | 15 to 30 | 0 to 1 | 0 to 4    | 0      |

- b. Decreases flow after hardening of amalgam
- c. Increases setting expansion
- d. Accelerates setting and thereby reduces setting time
- e. Resists tarnish and corrosion

**Tin:** Most of the alloys contain 25 to 28 percent (by weight) of tin but in some of the special alloys, it may be 0 to 30 percent. It has the following effects on the properties of amalgam.

- a. Increases setting time
- b. Reduces strength, hardness, and setting expansion.
- c. It has greater affinity for mercury hence helps in amalgamation

**Copper:** Generally it is used to replace the silver. It may be present 2 to 30 percent (by weight) in alloy. It has the following effects on the properties of amalgam.

- a. It increases the compressive strength
- b. It reduces flow and setting contraction of amalgam
- c. It helps in uniform comminution of the alloy during trituration

**Zinc:** Its presence is not essential, it may vary from 0 to 2 percent (by weight). It is seldom present more than 1 percent. It has the following effects on the properties of amalgam.

- a. It prevents oxidation during alloy ingot manufacture.
- b. It gives rise to delayed or secondary expansion if zinc containing alloys are contaminated with moisture.

**Palladium:** It may be present 0 to 1 percent (by weight). It improves the corrosion resistance and the mechanical properties.

**Indium:** It may be present 0 to 4 percent (by weight). In high copper alloy it enhances the clinical performance

of amalgam restoration as it reduces the evaporation of mercury and the amount of mercury required to wet the alloy particles.

## Properties

Mechanical properties of amalgam are as follows.

- Compressive strength of high-copper amalgam is more than low-copper amalgam and its value ranges from 380 to 550 MPa and is almost similar to enamel and dentin.
- Tensile strength of both high and low-copper amalgam is low and in this, high-copper has comparatively low tensile strength than low-copper amalgam.
- Amalgam is a brittle material
- Amalgam has creeping properties because there is slow metallurgical phase transformation during diffusion controlled reactions and it produces volume increase.

## Clinical Considerations

It is evident from clinical studies that high-copper amalgam restorations are better than low-copper amalgam restorations in following properties. High copper amalgams have following properties.

1. Less marginal breakdown
2. Less susceptible to corrosion
3. High compressive strength
4. No delayed expansion as usually there is absence of zinc component in the high copper amalgam alloy.

High-copper amalgam is better than low-copper amalgam due to absence of gamma-2 phase and microstructure of particles. Clinically it is evident that

amalgam can withstand compressive loading better than tensile loading, because compressive strength of amalgam is many times greater than tensile strength. At the margin of cavity, if amalgam restoration is thin in section, it will be easily fractured. Hence, during cavity preparation, margin of cavity should have butt joint (at 90 degree) between prepared tooth and margin of amalgam restoration. Bulk of restoration can easily withstand masticatory forces.

Amalgam is a metallic restoration. If not properly insulated with base or liner it may cause slight sensitivity after placement of restoration for few hours or days due to thermal conductivity or a minor current due to electrochemical coupling. This sensitivity is relieved by sealing of intersurface by corrosion products. This can be better managed by use of cavity varnish before placement of amalgam restoration. In case of inadequate dentin after removal of caries, pulp should be protected and a thermal insulating base should be placed before filling by dental amalgam.

Most of the amalgam restorations during their setting reactions undergo very little dimensional change. There is abnormal expansion of amalgam restoration in case of improper manipulation or improper condensation of amalgam. This abnormal expansion produces stress on dentinal wall of tooth and causes unusual sensitivity or pain. Problem of persistence of unusual postoperative sensitivity after filling of amalgam is solved by replacement of restoration.

Amalgam is insoluble and its outer surface and interface which is in contact with dental tissues, are susceptible to tarnish and corrosion. Plaque is conducive to surface corrosion of amalgam. Hence, external surfaces on dental amalgams should be relatively smooth to prevent plaque adherence. This smoothness prevents formation of crevice sites for electrochemical corrosion or for stress concentration during masticatory forces. At the interface, tooth structure becomes discolored due to penetration of discolored by-product of corrosion reaction. This can be minimized by use of cavity varnish.

Polishing of restoration material should be done after 24 hours for smoothness of surface of amalgam restoration. This smoothness prevents corrosion reaction at surface. But by clinical studies, it is evident that there is no extra clinical advantage of polished amalgam restoration than initially burnished restoration.

Therefore, polishing has been replaced by burnishing the surface after the condensation of amalgam for smooth surface.

Galvanic reaction occurs in those patients who have amalgam restoration and other dissimilar metal restoration and new amalgam restoration near to old amalgam restoration having different composition. This galvanic reaction produces very small amount of current which causes sensitivity or metallic taste or pain. After sometime, passivity occurs which leads to disappearance of galvanism. But in case of persistence of galvanism, adjacent amalgam restoration should be replaced by nonmetallic restoration for prevention of further deleterious effect to pulp.

The secondary caries or fracture of amalgam restoration involving only small portion, can be repaired by amalgam. In case of secondary caries cavity is prepared without removing the wall of old intact amalgam restoration. The loose fractured part, if any, is removed and then the filling is repaired by amalgam restoration.

## **BASES AND LINERS**

Generally, aim of operative treatment is to preserve and restore function, esthetics and the vitality of the tooth. For the protection of pulp, sound dentin is the best barrier between a restorative material and pulp. Many restorative materials which are used in operative dentistry have excellent properties for most of the dental restorations, but are unable to protect the pulp by various stimuli during their service in oral cavity. For example, in case of deep carious lesion in which when carious dentin is removed and a very thin layer of dentin is left, materials to protect the pulp are required before insertion of restorative materials. These materials are known as cavity bases and liners. Objective of use of bases and liners is the protection of the pulp by various stimuli, such as chemical, thermal, electrical and mechanical stimuli. Bases and liners may differ markedly in their clinical handling characteristics. In spite of some overlapping purpose of bases and liners, these are not used as substitute for one material for another.

In some cases, combination of liner and bases is used to protect the pulp from various stimuli.

### **Cavity Bases**

Bases are used for prevention of thermal and chemical irritation and supplement mechanical support during



condensation of amalgam and cementation of indirect restorations.

Materials used as bases are as follows:

1. Calcium hydroxide [ $\text{Ca}(\text{OH})_2$ ]
2. Zinc oxide eugenol
3. Zinc phosphate
4. Polycarboxylate
5. Zinc-silico-phosphate
6. Glass ionomer
7. Mineral trioxide aggregate (MTA)

Calcium hydroxide, MTA and zinc oxide eugenol are used as intermediary bases.

### **Calcium Hydroxide**

Calcium hydroxide can be used in:

1. Powder form and
2. Quick setting paste form under the trade name called—Dycal. It has 11 to 13 pH which is highly alkaline. It can be used in deep cavities as it neutralizes the acids produced by the microorganisms and acts as a sub-base to neutralize the irritating acidic component of restorative base and materials. It can be used as thick paste with distilled water.

Calcium hydroxide is not used in powder form as sub-base, as it does not stay in place when condensation forces are used during base giving and filling over it.

### **Zinc Oxide Eugenol**

Zinc oxide has peculiar pharmacologic action on pulpal tissues, and eugenol has topical anesthetic properties. Hence, it is termed an obtundent material. It takes long time to set and has insufficient compressive strength. When it is used as base it reduces discomfort of patient associated with dental caries and instrumentation during removal of dental caries. When unfilled and filled resins are used as restorative materials, zinc oxide eugenol is not used as base material, because eugenol interferes with polymerization process of resins. Hence, calcium hydroxide is used as base material under resin restoration.

### **Zinc Phosphate Cement**

Zinc phosphate cement consists of powder and liquid. Powder is zinc oxide and liquid is phosphoric acid. Setting reaction of zinc phosphate cement is based on acid-base reaction. It acts as an electrical and thermal insulator. Its linear coefficient of thermal expansion is

low. Its pH remains acidic for sometime after placing in cavity. So, it is not placed in deep cavity because it causes irritation to pulp, but it is used after placing a subbase of  $\text{Ca}(\text{OH})_2$  or Zinc oxide eugenol or of both.

### **Zinc Polycarboxylate Cement**

This cement consists of powdered zinc oxide and liquid polyacrylic acid. When used as base it acts as electrical and thermal insulator and has low linear coefficient of thermal expansion. Compressive strength of zinc polycarboxylate cement is 100 MPa.

### **Glass Ionomer Cement**

Glass ionomer cement consists of powder of ion leachable glasses and a copolymer of polyacrylic acid. This cement has thermal and electrical insulating properties. Compressive strength of glass ionomer cement is 120 MPa.

### **Cavity Liners**

Cavity liners are relatively thin film of material. They vary in thickness from a few microns to about a millimeter, and are used primarily to provide a protective barrier between dentin and the restorative material against irritants, minimize ingress of oral fluid at interface and give some therapeutic effect on dentin and pulp.

Cavity liners are of two types:

1. Cavity liner suspensions
2. Cavity varnishes
  1. *Cavity liner suspensions:* Cavity liner suspensions are used particularly with tooth-colored restorative materials. These are suspension of calcium hydroxide, zinc oxide and other materials in resinous solutions. Cavity liner suspensions are combination of resin film with alkaline calcium hydroxide and other basic metal oxides to provide a protective film having greater physical integrity as well as chemical neutralizing capacity for acids. Cavity liner suspension films are dissolved in oral fluids and cause severe microleakage. Therefore, these are used only on dentin surface and not on enamel surface.
  2. *Cavity varnishes:* Cavity varnishes are made of one or more resins derived from natural

## 104 Textbook of Operative Dentistry

gums, synthetic resins or resin dissolved in volatile agents like chloroform. On application on tooth, chloroform evaporates and thin film of resinous material remains on cavity wall. After evaporation of solvent, there are small pinholes in film. Hence, two or more films should be applied for continuous layer of varnish. Cavity varnish, which forms resinous film on wall of cavity, is not dissolved by oral fluid. Hence, cavity varnish are used on prepared cavity prior to insertion of amalgam, cast gold, cohesive gold, and certain other restorative materials because cavity varnishes reduce leakage of oral fluid. Cavity varnish also prevents discoloration of tooth by corrosion product of amalgam when used on wall of cavity prior to insertion of amalgam. Film of cavity varnishes is also destroyed by those restorative materials, which contain organic solvents causing reduced value of cavity varnishes.

### Clinical Considerations of Bases and Liners

Selection of base or liner depends upon following conditions—(1) thickness of remaining pulpal dentin (2) adhesive properties of the base or liners and (3) type of restorative material being used over the base and liner.

Usually there is no need for pulp protection measures when remaining dentin thickness is more than 2 mm. In case of amalgam restoration, varnish is used for prevention of microleakage at interface of restoration and tooth surface wall. In case of deep caries where remaining dentin thickness is less than 2 mm, calcium hydroxide liner or base and zinc oxide eugenol cement base are required for pulp protection. Both provide pulpal medication but their effect is different. Eugenol, from zinc oxide eugenol cement base acts as obtundent to the pulp. When composite or resin based restorations are used then zinc oxide eugenol is contraindicated for use as base and liner because eugenol interferes in polymerization process. In this case, calcium hydroxide is used as base or liner. In deep carious lesion in which remaining dentin thickness is 0.5 to 1 mm or pulp is near about to be exposed, 1 mm thick layer of calcium hydroxide or Mineral Trioxide Aggregate (MTA) is used for formation of reparative dentin.

Adhesive cement liners are used after removal of extensively carious dentin. Glass ionomer cement forms an adhesive bond both to enamel and dentin but polycarboxylate forms adhesive bond to dentin only.

## BONDING AGENTS

Bonding agents are classified on the basis of the primary adherence as enamel bonding systems and dentin bonding systems.

### Enamel Bonding Systems

Enamel bonding agents are composed mainly of a resin matrix diluted by other monomers to lower the viscosity. Enamel bonding agents help in increasing the wettability of acid-etched or conditioned enamel. When enamel bonding agents are placed onto acid-etched or conditioned enamel, the monomer flows into interstices between and within enamel rods. These monomers are polymerized towards tooth surface and form macrotags between enamel rod peripheries and microtags from across the end of each rod. On the outer surface of enamel bonding agents, it is copolymerized by restorative resins and form strong chemical bond. The bond strength depends upon film thickness of enamel bonding agent and shear strength of adjacent enamel rods and its value varies between 18 and 47 MPa.

### Dentin Bonding Agents

Dentin bonding agents bond to dentin through a chemical reaction. The bond formed is a weakened polar bond that binds the phosphorus in the bonding agent, a phosphate ester of Bis-GMA to the calcium in tooth structure. Ideally the dentin bonding agents have a hydrophilic part to displace water and thereby wet the surface of dentin and other hydrophobic part to bond restorative resins. Dentin bonding agents are divided into generations according to their development with time.

### Amalgam Bonding Systems

Amalgam bonding systems are like enamel and dentin bonding systems but in this, restorative material is amalgam in place of restorative resin. Amalgam bonding agents have hydrophilic and hydrophobic ends to complete the wetting of the surfaces of tooth and amalgam restoration. The enamel of tooth is hydrophilic and amalgam is hydrophobic in nature. In this way,

hydrophilic ends of enamel bonding agents interact with amalgam and hydrophobic ends interact with enamel. The 4-methyloxy-ethyl-trimellitic anhydride is used as amalgam bonding agent. Bonding strength of enamel bonding agent is very low and its value is 2 to 6 MPa.

Amalgam bonding agents have dentin sealing properties. Therefore, use of cavity varnish prior to placement of amalgam is not necessary if enamel bonding agents are used. In case of weakened tooth structure, its resistance form may be improved by use of relatively thick layer of amalgam bonding agent. In this, acid etched enamel or dentin holds amalgam bonding agent by micro-mechanical bond. In thick layer of agent, interlocking of microstructural features may take place during amalgam condensation and produce a strong bond.

### Cast Restoration Luting/Bonding Systems

Cast restorations are retained on prepared tooth with the help of tooth preparation designs and adhesive joint. This adhesive joint consists of intermediate material known as cement. Adhesive process of cement depends upon its adaptability to surface irregularities and it provides major strength to adhesive joint. The strength of joints is enhanced by (i) etching the surface of prepared tooth and casting surface, (ii) using stronger cements as composite cements, (iii) using reduced thickness of cement in joint and (iv) using composite with wetting materials. (For details refer the chapter on 'Bonding')

## OTHER RESTORATIVE MATERIALS

### Zinc Silico-phosphate Cements (ZSPC)

Zinc silico-phosphate cements consist of a mixture of silicate glass and zinc phosphate cement.

*Composition:* Powder contains an acid soluble silicate to which varying amounts of zinc and magnesium oxides are added. This powder is either mechanically mixed or fused together. Liquid in ZSPC is phosphoric acid.

*General properties of zinc silico-phosphate cements:* Zinc silico-phosphate cement is translucent and esthetically superior to zinc phosphate opaque cement. The clinical indications of zinc silico-phosphate cement are similar to that of zinc phosphate cement. Fluoride release from this cement is effective in caries inhibition.

Due to its translucency and high strength, it was used for cementation of ceramic restoration, but now-a-days the use of ZSPC is declining because of development of esthetically better materials such as resin and glass ionomer cements.

### Pit and Fissure Sealants

*Definition:* A pit and fissure sealant is a resin which is firmly bonded to the enamel surface and isolates the pit and fissures from the caries producing conditions of the oral environment. Pits and fissures in the occlusal surfaces of the teeth are very susceptible to decay. In deep pits and fissures topical fluoride treatments are least effective in preventing caries. Deep pits and fissures provide shelter for cariogenic factors and obstruct oral hygiene procedures. Therefore to prevent initiation of caries, the pit and fissure sealants have been developed to seal deep pits and fissures liable to develop caries, away from the cariogenic oral environment.

### Composite Restorative Resins (Filled Resins)

Dental composite is a physical mixture of silicate glass particles with an acrylic monomer. The silicate glass particles provide; (a) mechanical strength for cement, (b) produce light transmission and light scattering giving enamel like translucency. The acrylic monomer provides; (a) flow to penetrate into micro-mechanical spaces on etched enamel or dentin surfaces, (b) moldability for proper filling.

### Glass Ionomer Cement

It is called a glass ionomer as it contains a type of glass powder and carboxyl group containing ionomeric acid. In this aluminosilicate powder from silicates and poly-acrylic acid of polycarboxylates cements are used. It is also called as polyalkenoate cement or aluminosilicate polyacrylic cement (ASPA). It is used as a restorative material and also as a luting cement. It bonds with enamel and dentin hence cutting away of the natural tooth structure for retention form during cavity preparation is very much minimized. These are available as a powder and liquid or a powder only which is mixed with water.

## PURE GOLD

Pure gold is used in dentistry for direct filling in the following forms

- I. Gold foil
  1. Sheet
    - a. Cohesive
    - b. Noncohesive
- II. Preformed gold foils
  1. Ropes
  2. Cylinders (hand rolled and mechanically rolled)
  3. Laminated foils
  4. Strips
  5. Pellets (hand rolled and mechanically rolled)
  6. Platinized
  7. Extraply (Pre-rolled cylinders of foil)
  8. Corrugated
- III. Electrolyte precipitated gold powder
  1. Mat gold
  2. Mat foil (Mat gold plus gold foil)
  3. Gold–calcium alloy
- IV. Powdered gold—gold powered and encapsulated—Goldent.

## INDIRECTLY USED RESTORATIVE MATERIALS

The commonly used indirect restorative materials are the following.

1. *Cast metal restorative materials* : Various metals and alloys are used for cast metal restorations. Among them important are, gold alloys, silver–palladium alloys, wrought base metal alloys etc.
2. *Dental ceramic* : It is a ceramic suitable for use in dentistry. It is a compound of metals and non-metals. Metals used may be aluminium, calcium, magnesium, potassium, sodium, tin and titanium, etc. Non-metals may be silicon, boron, fluorine and oxygen, etc. Dental ceramics should have one or more of the following properties, i.e. castability, moldability, esthetics, acceptability, strength and abrasion resistance.
3. *Mock-up material*: It is a light-cured composite mock up material used to demonstrate cosmetic results made up of either resin or porcelain (direct or indirect) on the patient's teeth or on laboratory casts. The material's unique chemistry allows creation of rapid, inexpensive, 3-dimensional mock-ups in a matter of few minutes. It is self-sticking to tooth surface, requires no etchant or adhesive and can be easily removed with slight pressure. (For further

details 'A Textbook of Dental Materials with MCQs' by the authors may be referred).

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# 10

## *Selection of Restorative Materials*

The major objective for the treatment of the carious and damaged teeth is the restoration of the teeth to health, form, function and esthetics. To maintain the pulp in good health, material that provides maximum pulpal protection along with long lasting functional efficiency must be selected.

The restorative materials can be classified as (a) Permanent and temporary (b) Metallic and non-metallic. The following factors are considered for the selection of restorative material.

- I. Biological considerations of the tooth while selecting the restorative materials.
- II. Physical and clinical properties of the restorative materials.
- III. General factors considered while selecting restorative materials.

### **BIOLOGICAL CONSIDERATIONS OF THE TOOTH WHILE SELECTING THE RESTORATIVE MATERIALS**

#### **Size of the Carious Lesion**

Before the selection of the restorative material, the depth of the caries in the dentin and the surface decalcification is assessed. For posterior teeth, the restorative material should have good compressive, edge and tensile strength. If the posterior teeth are greatly destroyed by caries, and if the patient is willing, then gold cast restorations or metal ceramic restorations should be done. In anterior teeth, and also in posterior teeth if carious lesion is small, for esthetic reasons they can be restored with a tooth-colored restorative material. If the carious lesion is large and it involves numerous surfaces, full coverage metal ceramic or composite restoration should be done.

#### **Condition of the Pulpal Tissue**

By examination, excavation, pulp vitality testing, radiographs, and other methods the condition of the

pulp is studied. If by a carious lesion there is no threat to the health of the pulp, remove the caries avoiding pulpal exposure and then restore the tooth with permanent restoration.

A tooth with poor pulpal prognosis should be restored only after endodontic treatment. The questionable teeth, after removal of caries, are temporarily sealed with calcium hydroxide and reinforced with a thick mix of zinc oxide eugenol with a layer of zinc phosphate cement over it. After 8 to 12 weeks, evaluation is made to determine if pulpal changes have reversed to normal or not. If pulp has recovered and tooth is comfortable and symptomless the tooth can be restored permanently. If tooth becomes hypersensitive to the thermal changes or painful then endodontic treatment is done.

#### **Condition of the Periodontium**

The operative procedure must be performed only after evaluating the health status of the periodontium. Gingival color, texture, level of gingival attachment, pockets, bleeding tendency, etc. reveal the variations of the gingiva from the normal.

If teeth are covered by debris, or calculus, surrounded by diseased gingival tissues and are loose, they cannot be restored properly. By probing, and with the help of radiographs areas of gingival recession and furcation involvement are evaluated. If furcation involvement is present, prognosis of the tooth is poor and so it affects the restorative treatment plan. If a tooth surface in an area of gingival recession requires sub-gingival restorative margin, restorative procedures such as margination, and impressions etc. can aggravate the gingival problem. Mobility of the teeth signifies bone loss which adversely affects the operative treatment.

#### **Occlusion**

The static and dynamic occlusion must be carefully examined and analyzed before initiating restorative



## 108 Textbook of Operative Dentistry

treatment. Intercuspal position, overbite, overjet should be recorded. Nonfunctional contacts must be recorded so that they may be removed during restorative treatment. If abnormal wear patterns like bruxism are present, their contributing factors are to be removed.

### Size, Form and Structure of Teeth

If oversized restoration is done during mixed dentition period, proper eruption of the other permanent teeth may be impeded. Conversely, tooth alignment can be shifted if undersized restoration is done. When restoration of teeth with open proximal contacts is to be done, re-establishment of the space or slight alteration in the usual size of the tooth is to be decided. Sometimes it is desirable to alter the tooth form, or contour in the proposed restoration to improve the health of the supporting tissues. Recontouring of interproximal surfaces is usually done with gold castings and metal ceramic restorations, as they have greater convenience and accuracy, as mostly gold restorations and metal ceramic restorations are always made by indirect method. Amalgam often fails to close the contact and produce an ideal interproximal contour due to its physical properties, technique of placement and condensation.

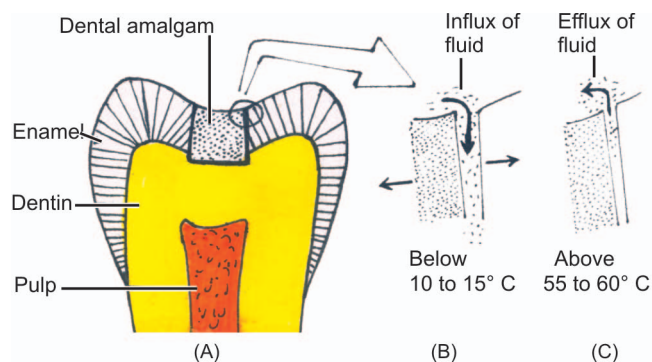
## PHYSICAL AND CLINICAL PROPERTIES OF THE RESTORATIVE MATERIALS

### Dimensional Stability

After the placement of the restoration in the cavity, changes in the dimension of the restorative materials take place due to setting reaction or due to thermal expansion or contraction. Shrinkage or excessive expansion of the restoration should not take place. After placement of the restorative material in the cavity, expansion of the material by few microns is desirable.

### Percolation

It is one of the consequences of difference of thermal expansion and contraction (linear coefficient of thermal expansion) between the restorative material and the adjacent tooth tissues. Ideally there should not be any difference between the two. The difference is directly proportional to the percolation (Table 10.1). Percolation gives rise to marginal leakage. Usually the temperature variation in the oral cavity due to different types of edibles called 'Oral thermal cycle' is between below 10°C



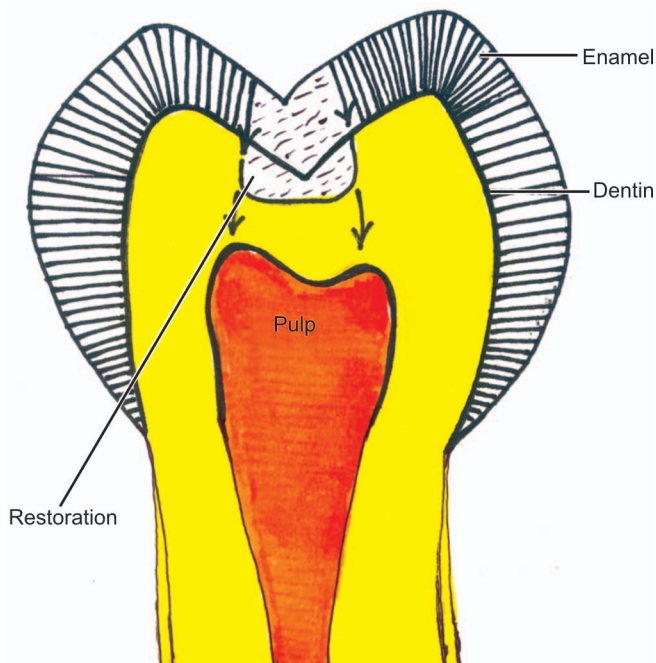
**Fig. 10.1:** (A) Percolation besides the margins of amalgam restoration due to the difference in linear coefficient of thermal expansion from tooth tissues during intraoral thermal cyclic changes. Oral fluid influx takes place during intake of cold food (amalgam contracts). Oral fluid efflux takes place during intake of hot food (amalgam expands). (B) and (C) are enlargement of encircled area in (A)

(Ice cream) and above 55°C (hot tea or coffee). Metallic filling shrink at lower temperature resulting in influx of oral fluid. Metallic filling expand at higher temperature resulting in narrowing of gap of interface and efflux of oral fluid (Fig. 10.1).

The more is the difference between linear coefficient of thermal expansion between the tooth structure and restorative material, more will be percolation and more will be the marginal leakage (Fig. 10.2) Therefore, as far as possible such restorative material should be selected

**Table 10.1:** Linear coefficient of thermal expansion (LCTE) of commonly used restorative materials and tooth tissues

| Restorative Dental Materials /<br>Tooth tissues | CTE ( $\times 10^{-6}$ / Degree<br>centigrade) |
|-------------------------------------------------|------------------------------------------------|
| <i>Tooth tissues</i>                            |                                                |
| 1. Enamel                                       | 11.4                                           |
| 2. Dentin                                       | 8.3                                            |
| <i>Restorative dental materials</i>             |                                                |
| 1. Dental Amalgam                               | 25                                             |
| 2. Type II Glass ionomer                        | 11.0                                           |
| 3. Gold Foil                                    | 14.0                                           |
| 4. PFM Ceramics                                 | 14                                             |
| 5. Aluminous Dental Porcelain                   | 4                                              |
| 6. Hybrid Glass Ionomers                        | 20 to 25                                       |
| 7. Packable Composites                          | 20 to 25                                       |
| 8. PMMA Direct –Filling Resins                  | 72 to 83                                       |



**Fig. 10.2:** Adaptation of restorative material is measured by leakage occurring around it in the direction of arrows. Oral fluids and microorganisms penetrate interface and through dentinal tubules and may irritate pulp

which have linear coefficient of thermal expansion as near to as that of tooth tissues as possible.

### Strength

The restorative material must have sufficient strength to sustain the masticatory forces. The strength of the restorative material is measured by their compressive and tensile strength. During mastication, occlusal surfaces of the posterior teeth receive maximum stress, so the restoration in these areas requires material of high strength. More the bulk or thickness of the restoration, greater is the strength so lesser are the chances of fracture of the restoration.

### Adaptability

It means the closeness and the amount of mechanical interlocking and sealing between the restoration and the walls of the cavity. An ideal restorative material should have both chemical and physical bonding to the tooth structure. Proper adaptation develops a hermetic

seal between the restorative material and the tooth structure and thus prevents the marginal leakage and development of additional caries and pulpal irritation. At present, in all the restorative materials, some amount of marginal leakage is observed.

The adaptability between the tooth structure and the restoration can be determined by the isotopes, dyes or the bacteria present at the interface of the restoration and tooth structure. Acid etching, use of liners and sound manipulation helps in increasing the adaptability of the material and thus reduces marginal leakage.

### Solubility Resistance

The amount of restoration after being placed in the cavity should not decrease. The loss in the amount of the restorative materials may be because the restoration gets dissolved in the saliva or oral fluids present in the oral cavity.

### Abrasion Resistance

Loss of weight and change in the surface contour takes place due to abrasion. Abrasion resistance is determined by the application of abrasives and other substances on the surface of the restoration. Abrasion resistance to wear and fracture is required more for the occlusal surfaces of posterior teeth and incisal edges of the anterior teeth. Mostly amalgam, gold, porcelain and metal ceramic crowns are used for restoration of excessively destroyed crowns of posterior teeth.

### Thermal Conductivity

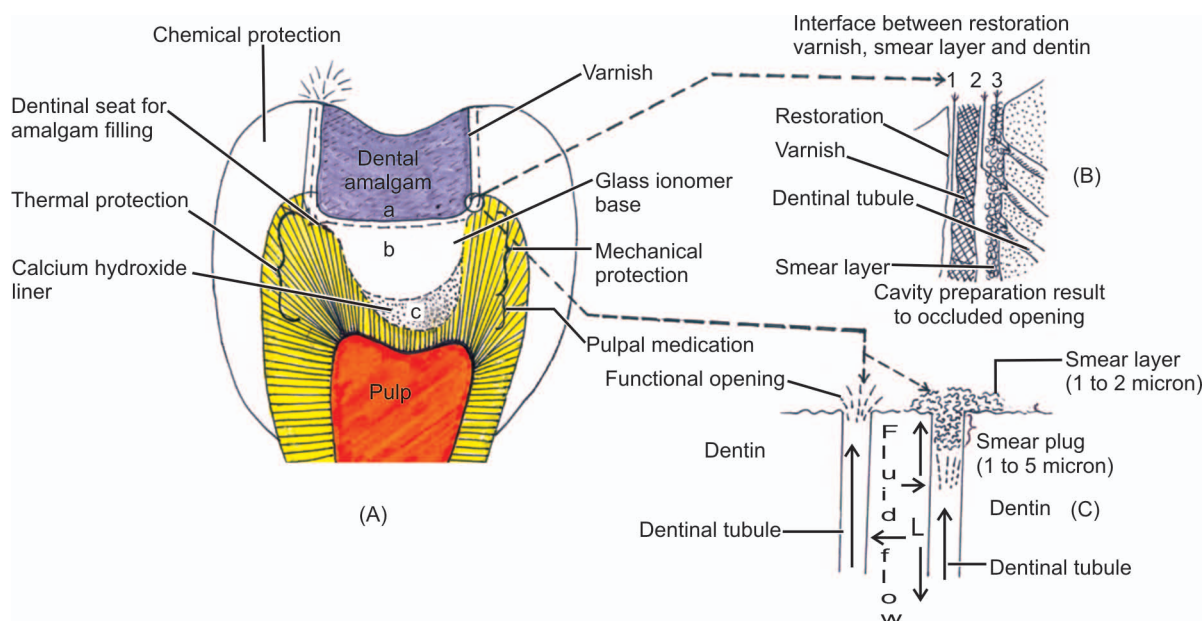
The material should have low thermal conductivity so as to avoid pulpal irritation.

In pulp protection following must be considered.

- A. Thermal protection
- B. Chemical protection
- C. Electrical protection
- D. Mechanical protection
- E. Pulpal medication

As the cavity becomes deeper and closer to pulp, protection becomes very important. Liners and bases are placed between deep dentin (sometimes pulp) and the restoration to provide pulp protection (Fig. 10.3).

- a. For shallow cavity, varnish or sealer is applied to the walls before filling
- b. For medium depth cavity liners are placed for thermal protection and pulpal medication. Seats in sound



**Fig. 10.3:** Use of liners and bases for amalgam restorations. [A] Prevention of Microleakage [B] and [C] are different views of enlargement of encircled area in figure (A). In figure (B) Possible routes of microleakage shown are 1. Between the varnish and restoration 2. Through the gap between the varnish and smear layer 3. Within or via the smear layer. In figure (C) Fluid flow from dentinal tubules are shown. Two-fold reduction in opening diameter results in sixteen fold reduction in fluid flow

dentin are provided for amalgam filling. These seats reduce the masticatory load which is transmitted to G.I. base and calcium hydroxide from the amalgam. Most of the masticatory load is shared by these seats of healthy dentin.

- c. In cavities close to pulp-for pulp protection a layer (about 1 mm thick) of light-cured calcium hydroxide is given in the area near to the pulp after removing infected dentin. Over this a base of glass ionomer is given (about 2 to 3 mm thick). Then the remaining cavity is lined with varnish and amalgam is filled. After giving calcium hydroxide liner in the deepest portion, amalgam bonding system can be used in place of liner and varnish if pulp is at least about one mm away (Fig. 10.3).

**Polymerization shrinkage**-Composite resins and all other resins shrink during polymerization (Table 10.2). The restorative material having least polymerization shrinkage should be selected.

**Table 10.2:** Polymerization shrinkage in various types of resins

| Resin                     | Polymerization shrinkage (%) |
|---------------------------|------------------------------|
| 1. Conventional composite | 1.5-2.0                      |
| 2. Microfilled composite  | 1.3-1.5                      |
| 3. Hybrid composite       | 2.2-2.5                      |
| 4. Acrylic heat cure      | 7.0                          |
| 5. Acrylic cold cure      | 3.5                          |

### Manipulation

The procedure for mixing and placing the material in the cavity should be easy. The mixing and working time for the material and the number of instruments required for mixing and filling should be reasonable.

### Resistance to Tarnish and Corrosion

The material should be resistant to tarnish and corrosion so as to prevent the degradation of the restoration surface. When dissimilar metals contact, tarnish and

corrosion are enhanced. In the oral cavity, pure gold and ceramics do not readily tarnish or corrode.

## GENERAL FACTORS CONSIDERED WHILE SELECTING RESTORATIVE MATERIALS

### Esthetics

Desire of esthetics is very important and it varies from patient to patient. Some patients object to any type of metal restorations, while others find that type of restoration quite acceptable. Before the restoration is done, the demand for esthetics by the patient and parent/spouse should be discussed.

### Economic Considerations

All the alternative treatment plans with their relative potential value, merits, demerits and financial involvements should be discussed with the patient. After obtaining consent of the patient, the restoration which is most appropriate for the patient is selected. The exact financial obligation of the patient is correctly estimated, and informed. After final decision the patient is fully informed about the treatment plan and mode of payment.

### Accessibility

Proper isolation and direct access is a must for doing restorative treatment in an area. In the posterior-most carious tooth and tooth having cemental caries, cast restoration by indirect method may be ideal, but for convenient approach and maximum conservation of tooth the structure, glass ionomer filling or multi-surface amalgam restoration can be done.

### Skill of the Operator

The factors limiting the restoration alternatives very often may be, the knowledge of the dental surgeon, his experience and ability to perform certain type of restorative procedure. Lack of laboratory support, patient and dental surgeon compatibility and nonavailability of specialist may also restrict the restorative options for the dental surgeon. Whatever best is possible under the circumstances in the interest of the patient should be done. For details 'A textbook of Dental Materials with MCQs' by the authors may be referred.

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# 11

## *Isolation of the Operating Field*

### **ISOLATION OF THE OPERATING FIELD IS VERY IMPORTANT IN OPERATIVE DENTISTRY**

#### **Advantages of Isolation**

The following are the main advantages of isolation of operating field.

1. A dry and clean operating field
2. Better access and visibility
3. Improved properties of dental materials hence better results are obtained
4. Protection of the patient and operator

Isolation of the operating field includes moisture control, retraction, improved visibility and better access and prevention of injury at the operating site.

#### **Moisture Control of Operating Field**

Moisture control refers to excluding saliva, sulcular fluid and gingival bleeding from the operating field. It also refers to preventing the handpiece spray and restorative debris from being aspirated or swallowed by the patient. The suction devices, rubber dam and absorbents are used for controlling the moisture.

#### **Retraction**

Retraction and access provide maximal exposure at the operating site. It usually maintains mouth opening and retracts the gingival tissue, lips and cheek. The high volume evacuator, absorbent, retraction cord and rubber dam are used for retraction and access (Figs 11.1 to 11.3).

#### **Prevention of Injury**

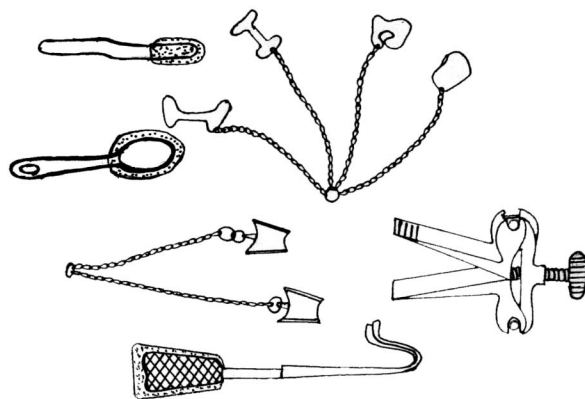
An important consideration of isolation of the operating field is preventing the patient from being injured during the operation. As with moisture control and retraction, the rubber dam, suction devices and

absorbents contribute to prevention of injury and also help in increasing patient's comfort and operator's efficiency. Local anesthetics play a role in controlling moisture because the patient is more comfortable, less anxious and less sensitive to oral stimuli hence less salivation occurs. Local anesthetics also reduce blood flow because they have vasoconstrictor, thus they help to control hemorrhage at the operating site.

#### **Isolation with Rubber Dam**

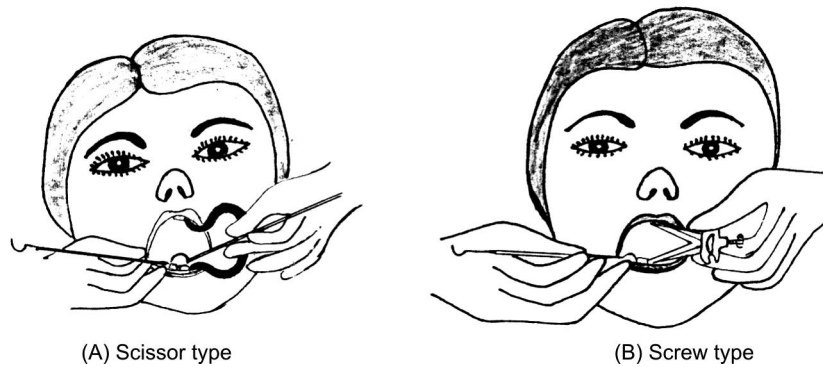
For the first time in 1864 Dr. Sanford Christie Barnum of New York City recommended the use of the rubber dam. The rubber dam eliminates saliva from the operating site, retracts the soft tissue and defines the operating field by isolation of one or more teeth from the oral environment. When very deep carious lesion is present, use of rubber dam is necessary to prevent or minimize pulpal contamination from oral fluids.

Rubber dam is available in light and dark shades. The dark colored rubber dam provides a good contrast with the teeth and reduces light reflection. The width of rubber dam is 12 cm (4.75 inch) and 15 cm (6 inch).

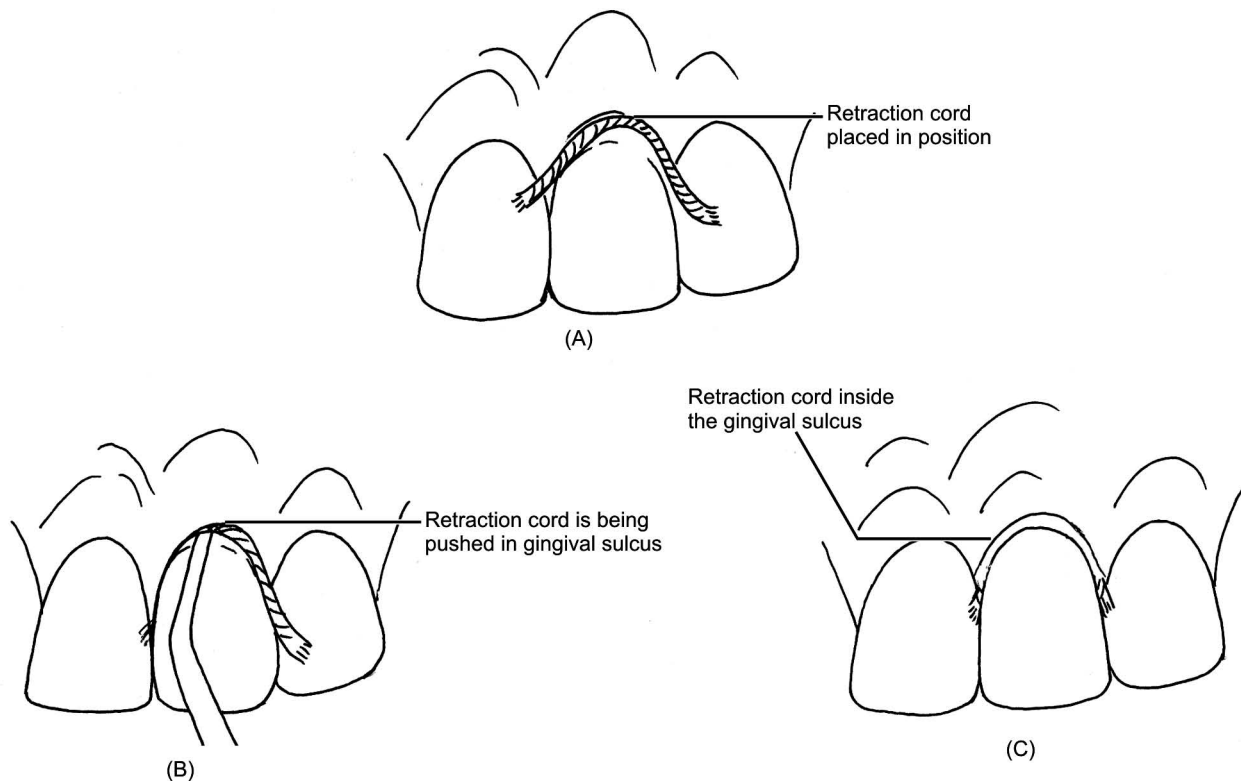


**Fig.11.1:** Various types of mouth props used to open and keep the mouth open





**Fig. 11.2:** Mechanical mouth props in use (A) Scissor type, (B) Screw type



**Fig. 11.3:** Placement of retraction cord for retraction of gingival margin

Twelve cm wide rubber dam is successfully used with the Young's frame (Fig. 11.4). Fifteen cm long rubber dam is used when employing the Endon frame (Fig. 11.5) or the elastic straps (Fig. 11.6). The thickness of rubber dam is 0.15 mm (0.006 inch) (thin), 0.2 mm (0.008 inch) (medium), 0.25 mm (0.010 inch) (heavy)

and 0.30 mm (0.012 inch) (extra heavy). For better gingival tissue retraction, the heavy (thick) rubber dam is usually employed. Young's frame is made up of metal and Endon frame is made up of plastic. Plastic frame does not interfere with X-rays hence preferred over metal frame.

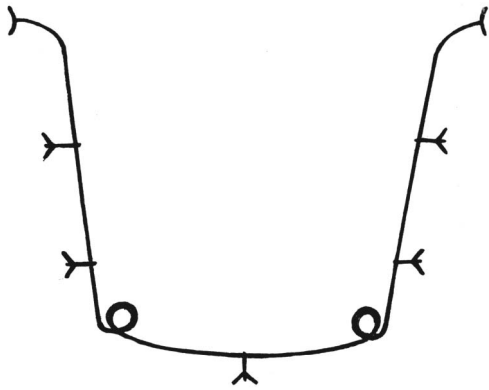


Fig.11.4: The Young's rubber dam frame holder

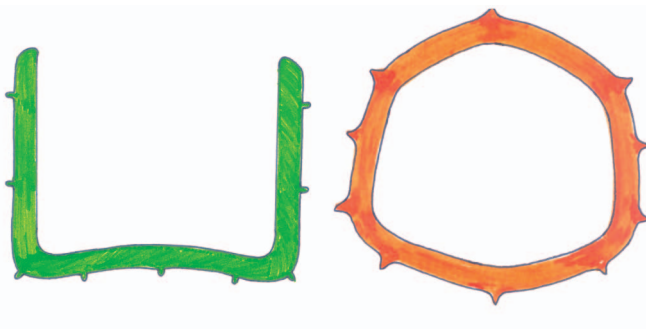


Fig. 11.5: Plastic rubber dam frame (Endon frame)

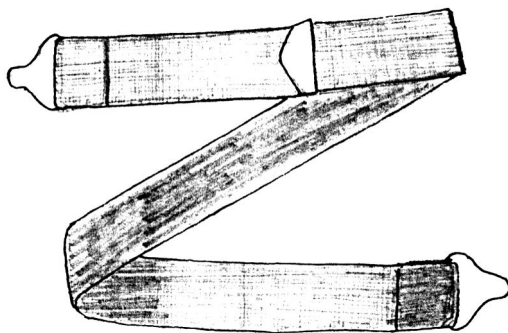


Fig. 11.6: Adjustable neck strap for use with the Endon or Young's rubber dam frame (holder)

Complete rubber dam kit with clamps is shown in Figure 11.7.

A wide variety of clamp designs are available to secure the rubber dam to a posterior tooth. The clamp

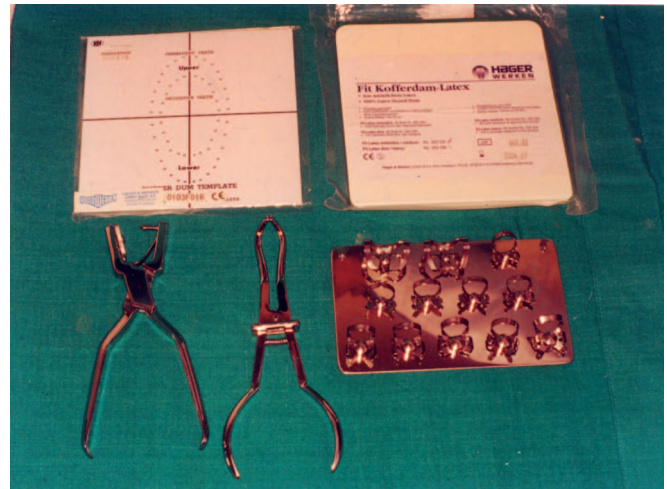


Fig. 11.7: Complete rubber dam kit with clamps, rubber dam punch and rubber dam holder

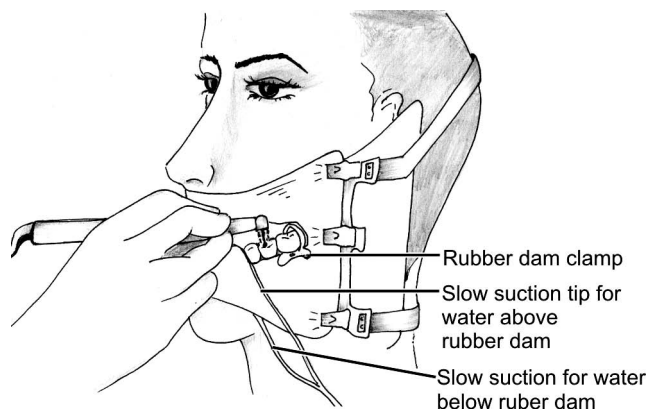


Fig. 11.8: Strap type rubber dam holder holding rubber dam in position. Airtor is being used in mandibular teeth. Two suction tips are being used. One above the rubber dam and another below the rubber dam

should be entirely stable on the tooth and should not impinge on the gingiva (Fig. 11.7).

A seal is provided around the neck of the tooth by everting the rubber dam at the cervical region. The Young frame or Endon frame can provide sufficient convenience with rubber dam and are often easier to apply on the teeth and are better tolerated by patients. Any frame will limit access to some posterior areas, when it is incorrectly applied to the tooth. Strap type rubber dam is held in position by straps running across behind the neck (Fig. 11.8).

### Procedure for Placement of Rubber Dam

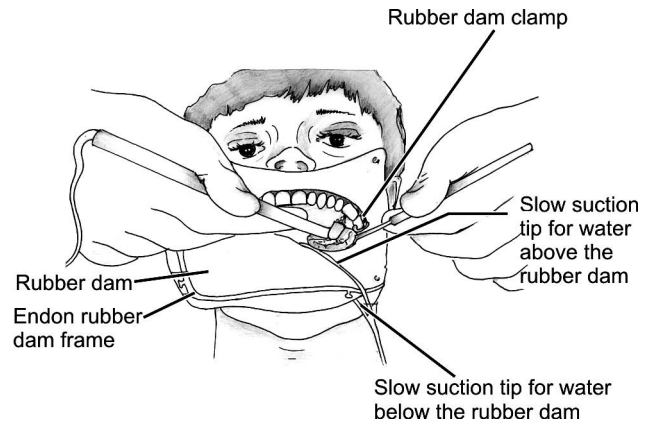
Before placing the rubber dam, the dental chair should be adjusted for optimal patient comfort and also, it may be necessary to remove debris and calculus from the surface of the teeth to be isolated. Before placing the rubber dam, local surface anesthesia should be applied for more comfortable placement of retainer on the anchor tooth.

Procedure for placement of rubber dam is easiest when four handed dentistry is practiced. The following are the steps for placing the rubber dam.

- Determine the size of the area to be isolated. As a general rule, if size of the area to be isolated is large, then access is better and isolation is easier. Most often, the size of the area to be isolated will include at least one tooth posterior and two teeth anterior to the tooth (teeth) being operated. Prior to rubber dam application, the area to be isolated must be clean.
- With dental floss determine proximal contact area for ease of passage of rubber dam. The operator receives dental floss from the assistant to test the interproximal contacts, to remove debris from the teeth to be isolated, for identification of any sharp edges of enamel that must be smoothed or removed to prevent tearing of the rubber dam. A blunt narrow bladed hand instrument may be used for wedging, if tight contacts are present between the teeth, to permit placement of the rubber dam.
- Rubber dam clamp must be stable upon the teeth and not cause damage to the teeth, to any restoration present in the teeth or to the surrounding tissues. For a clamp judged to be appropriate, first a piece of dental floss is tied to it, then the dental floss is tied onto the tooth to establish its stability and soft tissue relationship.

Rubber dam clamp forceps carry the clamp to the lingual cervical region first and then are rotated to carry it to the buccal cervical region of the tooth. By this method, four point contacts of the clamp with the cervical area of the tooth are formed.

- A rubber dam sheet is selected and very small piece from the upper right side corner of sheet is trimmed off with scissors in order to recognize and reorient the dam position during the succeeding steps. The position of the holes to be punched is established after careful study of the arch form, tooth alignment and variation as required for an individual case or using standard template and with rubber dam stamp method (Figs 11.9 to 11.12).



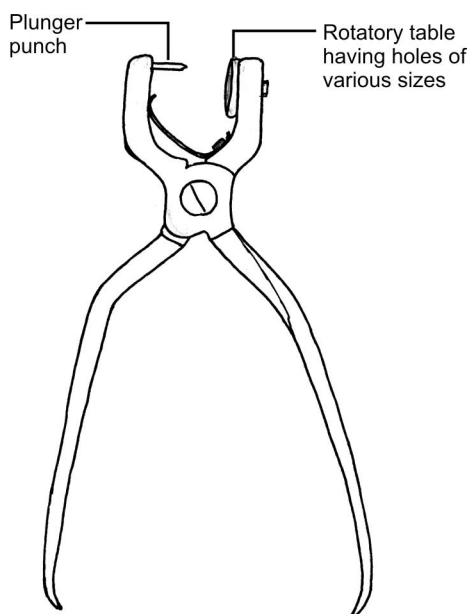
**Fig. 11.9:** Young's or Endon rubber dam frame holder holding rubber dam in position. Airtor is being used in maxillary teeth. Two suction tips are used. One above the rubber dam and another below the rubber dam



**Fig. 11.10:** The use of Rubber dam, wedges, ligation thread and winged rubber dam clamp



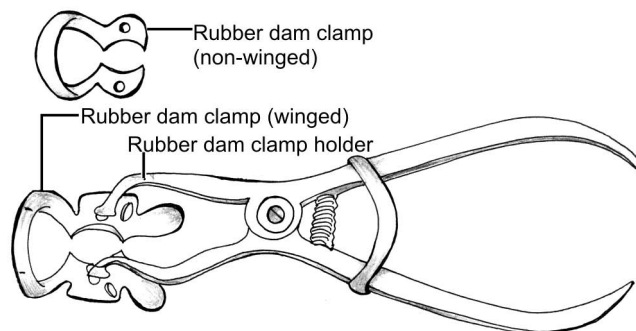
**Fig. 11.11:** Rubber dam isolation during biomechanical preparation in root canal treatment in lower first molar



**Fig. 11.12:** Rubber dam punch

Holes punched through the rubber dam should be of the small enough size to permit a snugness around the neck of the tooth and large enough to avoid the possibility of tearing during application of rubber dam. Smaller holes are used for mandibular incisors, middle sized holes are used for premolars, canines and maxillary incisors and larger holes are used for molars. Spacing present between the two holes should be sufficient to allow the rubber dam to completely encompass the interdental papilla, thus bringing about its retraction. Insufficient space present between the holes causes slippage of the rubber dam to the mesial or distal of the papilla rather than encompassing the interdental papilla. Too great a spacing between holes allows the excess rubber dam to bunch up within the interdental space. This may interfere with instrumentation during operative procedure. Normal spacing present between the holes is about 4 mm, except in the maxillary anterior region. In this area, a 5 mm width of rubber dam is present between the two holes. Buccal or lingual positioning of hole should be made for teeth which are placed in buccoversion or linguoversion.

- e. Using a cotton roll or fingertip apply the lubricant to both sides of the rubber dam in the area of punched holes. This facilitates passing the rubber dam through the contact area.
- f. Winged clamps permit the rubber dam to be stretched over the wings. This facilitates their proper placement (Figs 11.13 and 11.14)



**Fig. 11.13:** Rubber dam clamp holder holding winged rubber dam clamp

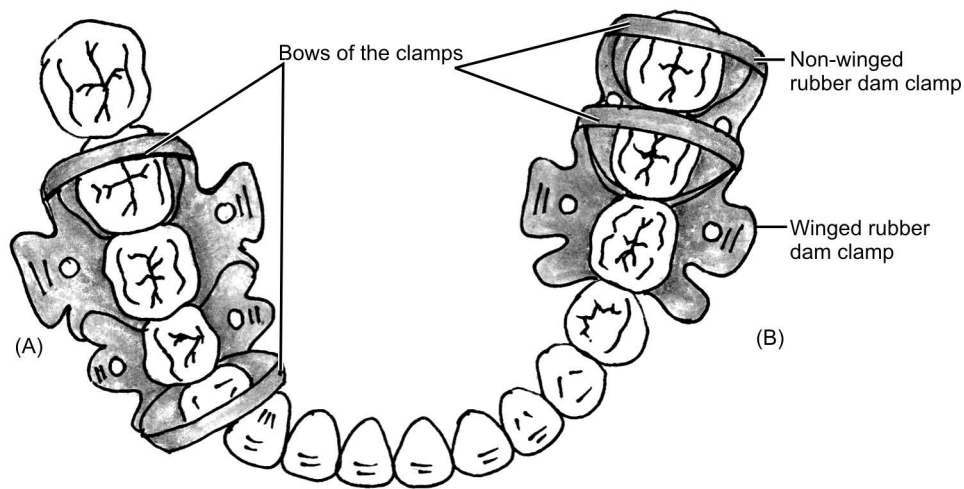
A wingless clamp is often applied with the rubber dam, which is already stretched around its bow.

The wingless clamp may also be positioned onto the tooth (to be operated) first, followed by stretching of the appropriate hole of the dam over it and around the cervical region of the tooth. Once the clamp and dam are seated, the dam is stretched from the clamp to the farthest tooth to be isolated. At this time, it is often desirable to set the frame.

- g. Rubber dam passage through the contact area should be started with a single edge and continued with a single thickness. Pass the dam through as many contacts as possible without using dental tape, because dental tape always increases the risk of tearing holes in the septa. Slight wedging of the teeth is sometimes necessary for aid when the proximal contacts are extremely tight. The blunt hand instrument applied in the facial embrasure, gingival to the contact area is usually sufficient to obtain enough separation to permit the rubber dam to pass through the contact areas.

Use of waxed dental tape is preferred over dental floss because its wider dimension makes passage easier and decreases the chances for cutting holes in the septa or tearing the edge of the holes.





**Fig. 11.14:** For extra security during operating on a lower first molar, double clamp application may be done, clamps may be mounted with bows in either direction. [A] Bows of the clamps in opposite direction [B] Bows of the clamps in same direction

With a firm and good finger rest on the tooth, the tape should be controlled so that it slides easily through the proximal contacts, thus preventing damage to the interdental tissue. Once the leading edge of the rubber dam has passed through the contact, the remaining interdental rubber dam can be carried through more easily.

- h. Inversion of the edge of the rubber dam at each hole present on to the cervical area of the tooth. Completion of the inversion of facial and lingual region of cervical area of the tooth is done by moving the explorer around the neck of the tooth facially and lingually with the tip, perpendicular to the tooth surface or directed slightly gingivally. Apply a continuing air stream on the area to dry the tooth and rubber dam. Applying a gentle apical pressure at the edge of the hole with a spoon excavator or side of an explorer tip will aid in everting the rubber dam. Ligatures about the neck of the teeth should be avoided. They are used only when necessary to stabilize the rubber dam or to provide additional forced retraction. Their placement tends to be traumatic to the gingival tissue, particularly in the anterior region of the jaw.

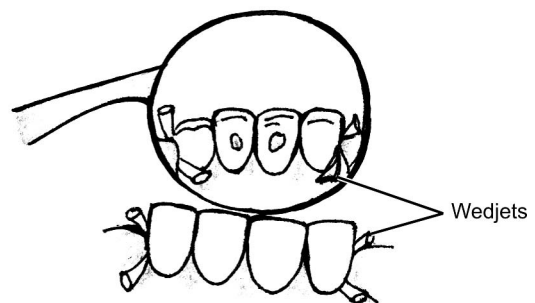
The lips and the corners of the mouth should be lubricated with petroleum jelly or cocoa butter. This prevents any abrading action of the rubber dam on these tissues.

## WEDJETS

Wedjets are small pieces of thin elastic cord. They are used in the isolation of anterior teeth for holding the rubber dam in place. They are flossed over the rubber dam in the interproximal areas of the teeth, holding the rubber dam in position (Fig. 11.15)

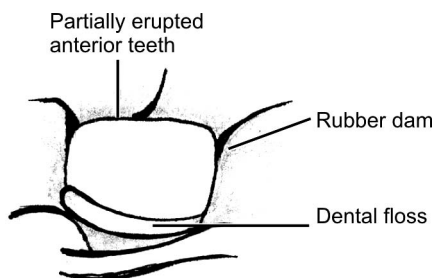
Rubber dam isolation of partially erupted anterior tooth can be facilitated by tying the rubber dam on individual tooth by dental floss (Fig. 11.16)

To increase stabilization of a rubber dam clamp or to retain the position of the dam in the anterior region of the jaw, a small amount of dental impression compound is softened over an alcohol flame and applied



**Fig. 11.15:** Isolation of the lower incisors can be done by holding rubber dam interproximally by placing wedjets (a thin elastic cord) that is flossed between the contact areas of the teeth over the rubber dam holding it in place





**Fig.11.16:** Rubber dam isolation of partially erupted incisors can be facilitated by tying rubber dam with dental floss around an individual tooth

to the dry teeth beneath the bow of the clamp first and then around the bow.

### Procedure for Removal of the Rubber Dam

Remove wedges in the same direction in which they were inserted. Cut away tied thread or tape from around the neck of the teeth. Stretch the rubber dam facially and pull the septal rubber away from the gingival tissue and the tooth. Protect the underlying soft tissue by placing a fingertip beneath the septum. Free the dam from the interproximal space, but leave the rubber dam over the anterior and posterior anchor teeth. The pressure holding the clamp on the tooth is released slowly. Once the retainer is removed by the operator, release the dam from the anchor tooth and remove the dam and frame simultaneously. Wipe the patient's lips with napkin immediately after the dam and frame are removed. This helps to prevent saliva from getting on the patient's face. Rinse the teeth and mouth by using air-water spray and the high volume evacuator. To enhance circulation, massage the tissue around the teeth that were isolated. Hold the sheet or rubber dam up to the operating light to determine that no portion of the rubber dam has remained between or around the teeth. Such a remnant will cause gingival inflammation.

### Advantages

The rubber dam is the most useful method of isolating the operating field. The advantages of the rubber dam are as follows.

- i. It creates a dry, clean operating field
- ii. Improves access and visibility

- iii. Improves properties of dental materials as ideally all the materials require a dry field for best results.
- iv. It provides protection to the patient from accidentally fallen instruments and materials etc.
- v. Increases operating efficiency and output of the work as frequent rinsing by the patient is avoided.

### Disadvantages

- i. Time consumption and patient's objection, as it looks uncomfortable to the patient.
- ii. Patients suffering from asthma, psychological problems, allergy to latex may not tolerate the rubber dam.
- iii. Certain conditions may prevent the use of the rubber dam. These are: (1) incompletely erupted third molar, (2) malposed teeth, (3) teeth that have not erupted sufficiently to receive a retainer (clamp).

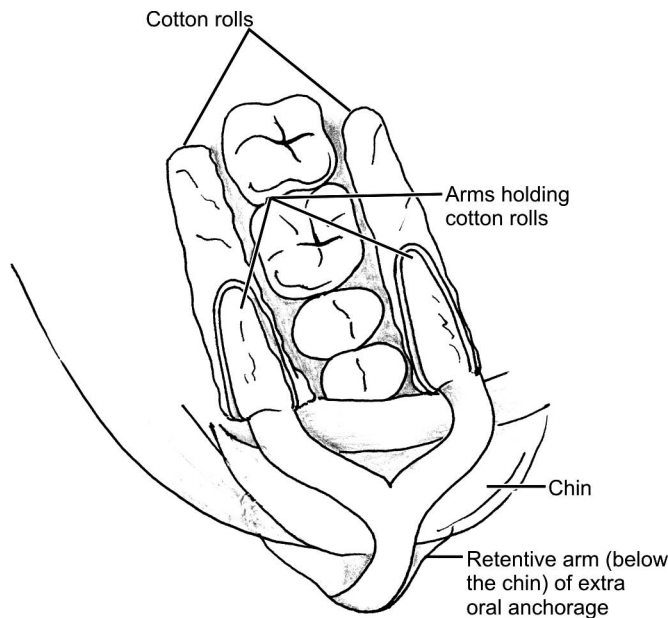
### Absorbents (Cotton Roll and Cellulose Wafers)

Cotton rolls and cellulose wafer absorbents are helpful for short period of isolation, for example in examination, polishing, sealant placement, and topical fluoride application. Absorbents play an important role in isolation of the teeth. When rubber dam application is impossible, absorbents provide dryness for procedures such as impression taking and cementation. Several commercial devices for holding cotton rolls in position are available (Fig. 11.17).

An advantage of cotton roll holders is that the cheeks, lips and tongue are slightly retracted from the teeth, which enhances access and visibility. The maxillary teeth are isolated by placing a medium sized cotton roll in the buccal/facial vestibule. Mandibular teeth are isolated by placing a medium sized cotton roll in the vestibule and a larger sized cotton roll is placed between the teeth and tongue. Cellulose wafers may be used to retract the cheek. The saliva ejector may be positioned, after the cotton rolls or cellulose wafers are in place. To prevent injury to oral soft tissues, it is better to wet the rolls and wafers before removal from oral cavity.

### Throat Shield

This is particularly important when the tooth being treated is present in the maxillary arch. An unfolded



**Fig.11.17:** Cotton roll holder with extra oral anchorage

gauze sponge, spread over the tongue and posterior part of the mouth is helpful in recovering a restoration like inlay or crown if it is dropped in the oral cavity. Without throat shield, it is possible for a restoration to be accidentally aspirated or swallowed. Throat shields are not well tolerated by some patients as they produce gagging. Therefore to reduce gagging, topical anesthesia can be used.

### Additional Methods for Isolation

- i. *Evacuator tip and mouth mirror retraction:* When use of the rubber dam is impractical or impossible, evacuator tip and mouth mirror may be used to retract the cheek, lip and tongue.
- ii. *Mouth prop:* A mouth prop should establish and maintain suitable mouth opening, thereby permitting cavity preparation on posterior teeth. The characteristics of mouth prop are as follows-
  1. It should be capable of being easily positioned in the oral cavity of the patient without any discomfort.
  2. It should be easily and readily removable by the operator or the patient in case of an emergency.
  3. It should be either disposable or sterilizable.
  4. It should be adaptable to all mouths

- iii. *Retraction cord:* When use of rubber dam is impractical, retraction cord moistened with a non-caustic styptic may be placed in the gingival sulcus for isolation and retraction in the direct procedures of treatment of cervical lesion, to control the sulcular seepage and/or hemorrhage. Retraction cords are available in normal size without the vasoconstrictor and with the vasoconstrictor, such as epinephrine, which also acts to control sulcular fluid of the operating site. A properly applied retraction cord will improve visibility and access, particularly in cervical lesion and also helps to prevent abrasion of gingival tissue during cavity preparation (Fig. 11.3).

### Drugs

To control excess salivation, occasionally Atropine is the drug which is used in restorative dentistry, although it is rarely indicated. Atropine is contraindicated for nursing mothers and for patients with glaucoma.

### CHEEK-TONGUE RETRACTOR AND DOUBLE ENDED ASPIRATION TIP

It is a dual function double ended aspiration tip. One aspiration tip is kept on lingual side and another on the facial side. It aspirates from both sides and also retracts both cheek and tongue. Treatment along with aspiration can be done by one single person by using this type of aspiration tips. Another advantage is that if by chance one end gets clogged, another end can keep on aspirating (Figs 11.8 and 11.9).

### LIP-EX RETRACTORS

They expand the mouth opening more in the vertical rather than horizontal direction. This makes them ideal for use when working on the gingival border of upper and lower front teeth and for the adjustment of orthodontic bands.

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## 120 *Textbook of Operative Dentistry*

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# 12

## *Instruments and Equipment for Tooth Preparation*

To comply with all steps and requirements of cavity preparation in the tooth, enamel, dentin and cementum, which are the hard tissues, are required to be partially removed and shaped with specific instruments in an ordered sequence. Before the advent of rotary instruments, removal of tooth tissue was a difficult process and was accomplished entirely by the use of hand instruments for cutting. With the introduction of high speed rotary powered cutting instruments, the cavity preparation, to receive restorative materials, can be completed with ease and much less effort and much faster.

However, the hand instruments remain an essential part of the armamentarium because they are used to refine the cavity preparation, to insert, manipulate and finish the restorative material.

### **HAND INSTRUMENTS FOR CUTTING**

#### **Materials Used for Manufacturing**

Most of the hand cutting instruments are manufactured mainly from carbon steel or stainless steel. The carbon-steel alloy contains 0.5 to 1.5% carbon and the rest is iron. The instruments of this alloy are known for their hardness and sharpness. The disadvantage with the instruments of this material is susceptibility to corrosion and the instrument fractures if dropped. Sharp cutting edges are the advantage with this material.

Stainless steel alloy contains 72 to 85 percent iron, 15 to 25 percent chromium and 1 to 2 percent carbon. By depositing a chromium oxide layer on the surface of the metal, (chromium reduces the tendency to tarnish and corrosion) it remains bright in most of the conditions. The disadvantage with stainless steel instruments is that they quickly lose their sharpness of edge, so it is difficult to maintain their sharpness.

In addition to the above materials, carbide and stellite are also used to manufacture the instruments. In some

cutting instruments carbide 'inserts' provide more sharp and durable cutting edges. Carbide is hard, wear resistant and brittle and can only be used in limited designs. Instruments made from stellite are hard and highly resistant to acids. Stellite consists of 65 to 80 percent cobalt, 10 to 35 percent chromium and 2 to 5 percent of tungsten, molybdenum and iron.

#### **Heat Treatment of Materials**

After bending the carbon or stainless steel to the structural design, they are submitted to two heat treatments—hardening and tempering. For hardening, 1 to 2 mm of instrument tip is heated to 1500 to 1600°F and then quenched. By hardening treatment, the alloy becomes brittle. Tempering heat treatment is done to relieve the strains and increase the toughness. In tempering, the tip is heated at lower temperature and then quenched in solutions of oil, acid or mercury.

#### **Parts of Hand Cutting Instruments**

A hand instrument is composed of three essential parts (Fig. 12.1):

1. Handle or shaft
2. Shank
3. Blade or nib

#### **Handle or Shaft**

The handle is used to hold the instrument. They are available in various sizes and shapes, which is helpful for better grasping and developing pressure. Earlier, instruments had handles of quite large diameter and were to be grasped in the palm of the hand.

Nowadays, instrument handles are smaller in diameter, may be smooth or eight-sided, knurled or serrated. On the handle of the instrument, the instrument number, series and manufacturer's name are written.

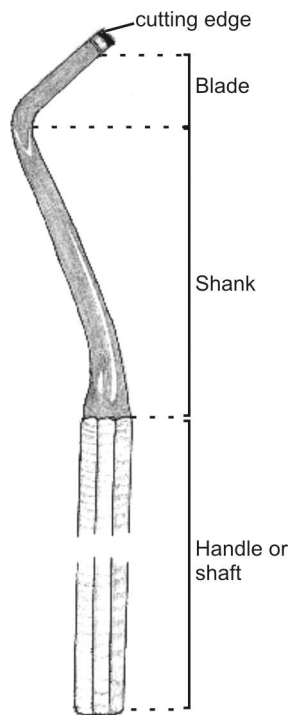


Fig. 12.1: Parts of a hand instrument

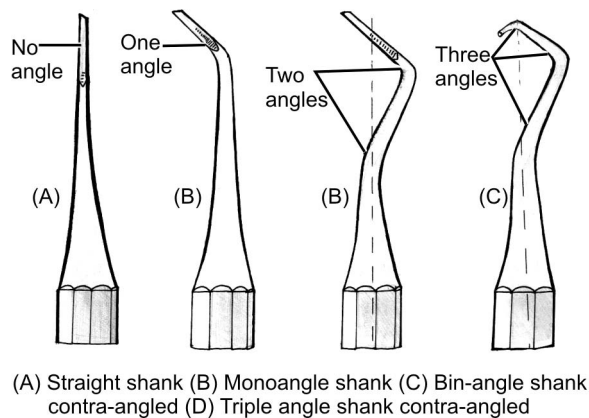


Fig. 12.2: Angles of the shank of most commonly used hand instruments

### Shank

It connects the handle with the working point or nib of the instrument. It tapers from the shaft (handle) down

to the blade and is normally smooth, round or tapered. The shank may be straight or may be bent for better control of the working point when force is applied. Closer the working point to the long axis of the handle better will be the control on it. For better control the working point should be near preferably within 3 mm of the center of the long axis of the handle. According to the number of angles, the instruments are classified as (A) straight, (B) mono-angle (one), (C) binangle (two), (D) triangle (three). If shank has more than one bends it is termed as contra-angled (Figs 12.2 (C), (D) and 12.3).

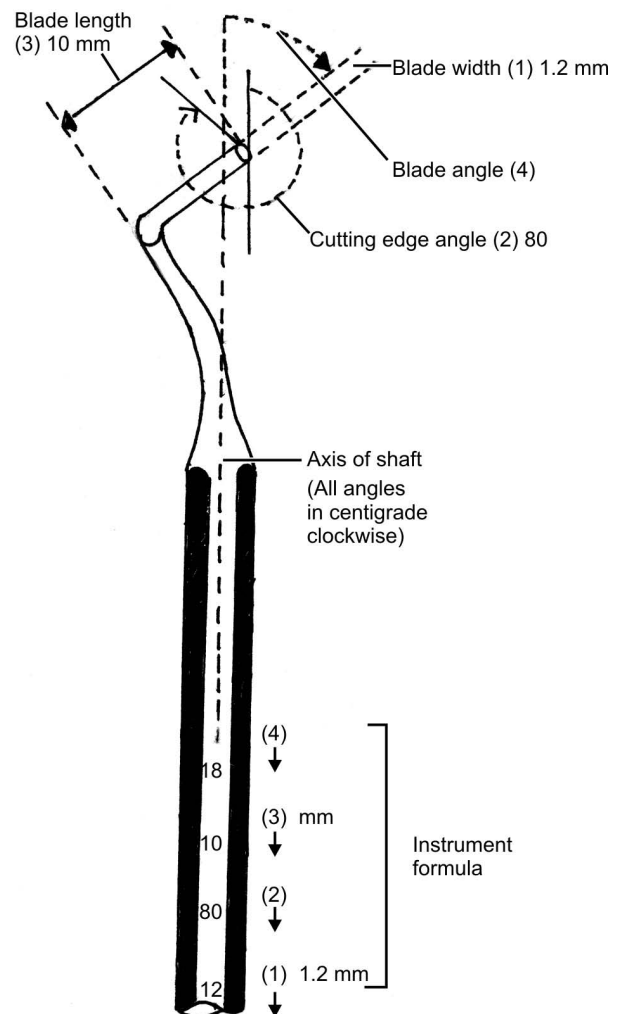
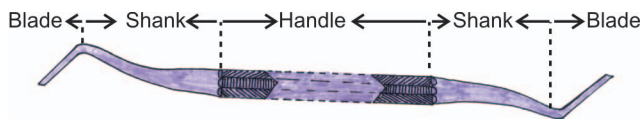


Fig. 12.3: Shank and blade with contra angle design of enamel hatchet showing measurement of angle of cutting edge. Primary cutting edge is positioned close to axis of the handle (In centigrade) to keep better control during use



**Blade or Nib**

Blade or nib is the working point. It is connected to the handle by the shank. To cleave and smoothen the enamel and dentin, the working point has a cutting edge and is called blade, while for non-cutting instruments, the working part is termed the nib and is used to input, adapt and condense the materials in the cavity. Depending on the materials being used, the surface of the nib may be plain or serrated. For gold and amalgam condensation, the tip must be serrated or criss-crossed. If instrument has blade on both the ends of the handle, it is known as 'double-ended' instrument. In such cases, one end is for the left side and other for the right. In some cases of the double ended instruments, similar blades of different sizes or shapes are present (Fig. 12.4)



**Fig. 12.4:** Double ended instrument showing three component parts—blade, shank and handle of hand instrument

## TERMINOLOGY AND CLASSIFICATION FOR INSTRUMENTS

Similar to biological classification, Dr. Black prescribed following nomenclature for the instruments.

1. Order — function of the instrument, e.g. excavator, condensor
2. Suborder — position, mode or manner of use, e.g. hand condensor
3. Class — design or form of the working end, e.g. hatchet, spoon excavator
4. Sub-class — shape of the shank, e.g. bin-angle, contra-angle

These names are combined to give a complete description of the instrument. Sometimes the sub-order is omitted due to variable and non-specific use of the instrument. For example, the instrument will be named according to the classification as bi-angle enamel hatchet or bi-angle spoon excavator.

Dr. GV Black classified the operative instruments according to their use and function into following six classes.

*Cutting instruments:* They are of two types.

- A. Hand—hatchets, chisels, hoes, excavators and others
- B. Rotary—burs, diamond abrasive points stones, disks and others

*Condensing instruments:* Pluggers-hand, mechanical

*Plastic instruments:* Spatulas, carvers, burnishers, packing instruments

*Finishing and polishing instruments:*

- A. Hand—Orange wood sticks, polishing points, finishing strips
- B. Rotary—Finishing burs, mounted brushes, mounted stones, rubber cusps, impregnated disks and wheels

*Isolation instruments:* Rubber dam frame, clamps, forceps, punch, saliva ejector, cotton roll holder, evacuating tips and equipment.

*Miscellaneous instruments:* Mouth mirrors, explorers, probes, scissors, pliers and others.

## BLACK'S INSTRUMENT FORMULA

The formula, engraved or printed on the handle consisting of a code of three or four numbers separated by dashes or spaces describes the dimensions and angulation of the hand instrument.

The first number of the formula indicates width of the blade or primary cutting edge in tenths of a millimeter (10 = 1.0 mm).

The second number represents the angle formed by the primary cutting edge and central axis of the instrument handle in clockwise centigrade. The instrument is positioned in such a way that the number always exceeds 50, and is measured in clockwise centigrades. If the cutting edge is at right angle to the length of the blade, then this number is omitted.

The third number (second number in three number code) represents the length of the blade in millimeters.

The fourth number (third number in three number code) represents the angulation which the blade forms with the long axis of the handle in clockwise centigrade. The angle is expressed in clockwise centigrade. To keep balance during working, tip of blade is brought in the line of the long axis of the handle.

### Bevels in Cutting Instruments

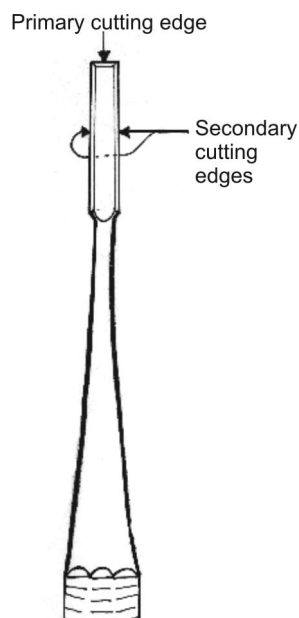
There is a single bevel in most of the hand cutting instruments that forms the primary cutting edge. If two additional cutting edges extend from the primary cutting edges, then the instrument with secondary cutting edges is called *bibeveled instrument* (Fig. 12.5).

Single-beveled direct cutting instruments such as enamel hatchets are made in pairs having bevels on opposite sides of the blade. The primary cutting edge is held downwards and pointing away. If bevel is on the right side of the blade, the instrument is right sided and if bevel is on the left side of the blade the instrument is left sided.

If the inside of the blade curvature or the primary bevel is not visible then the instrument has a distal bevel and if the primary bevel can be seen the instrument has a mesial or reverse bevel.

### Types of Hand-cutting Instruments

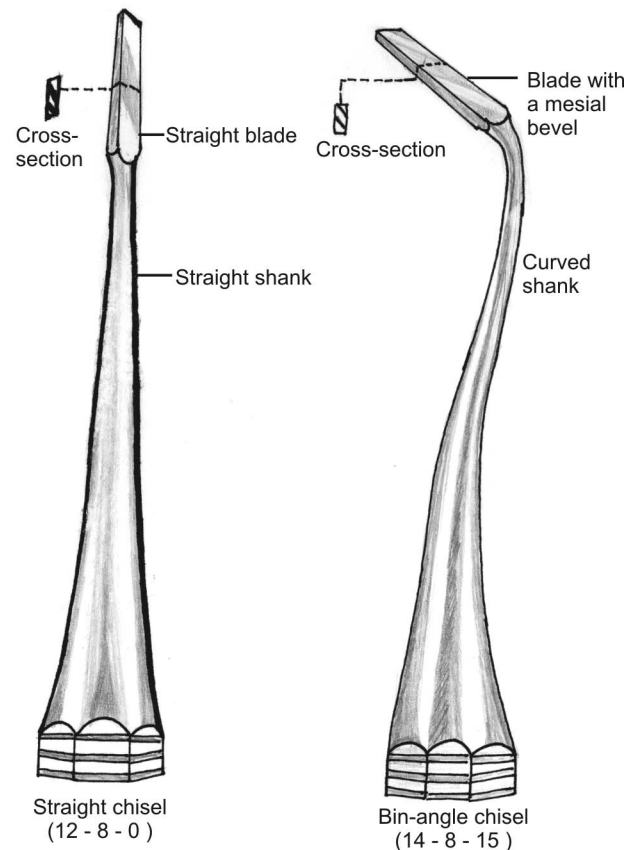
1. *Chisels*—The chisel is used to fracture and cleave the hard tissues of tooth. In straight chisel the cutting edge is perpendicular to the long axis of the handle and is used for gingival restoration of the anterior teeth. In angled chisels, the



**Fig. 12.5:** Primary and secondary cutting edges shown in blade design of a bibeveled chisel

primary cutting edge is in a plane perpendicular to the long axis of the shaft and may have either a mesial or distal bevel. They are applied with a push or pull motion for anterior proximal restorations, smoothing proximal walls and gingival walls for full coverage restorations (Figs 12.5 and 12.6).

2. *Hoe*—It is a form of modified chisel in which the angle of the blade is greater than 12.5 degree centigrades. It is used with a pull motion (Fig. 12.7)
3. *Hatchet*—It is a paired instrument in which the blade is almost perpendicular to the long axis of the handle but has no bevels on one side, used in a chopping motion to refine line and point angles (Fig. 12.8).
4. *Angle former*—It is a type of excavator which is monangled with the cutting edge sharpened at right and left angles to the long axis of the blade.



**Fig. 12.6:** Examples of chisels with corresponding instrument formula



Fig. 12.7: Hoe-used with a pull motion

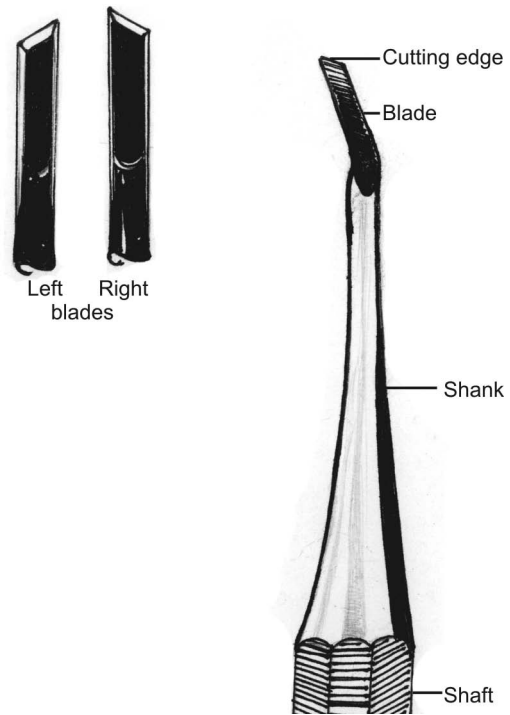


Fig. 12.9: Angle former

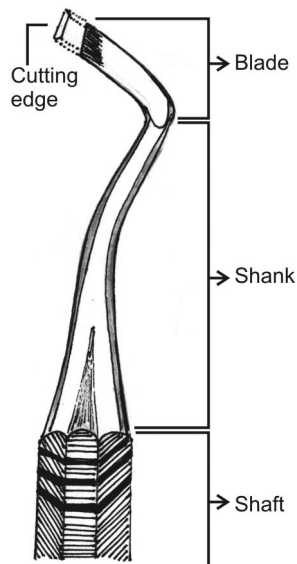


Fig. 12.8: Binangle hatchet, left

It is used with a push or pull motion for making retentive forms in direct filling gold restoration (Fig. 12.9).

5. *Spoon excavator*—It is used to remove caries etc. in the spooning or scooping action from the

carious teeth with large cavity. In the spoon excavator, the cutting edge is rounded (Figs 12.10 A to E)

6. *Gingival marginal trimmer*—It is like the hatchet, but the blade is curved and the cutting edge is other than right angle to the axis of the blade. It is used to give bevel in gingival enamel margin of proximo-occlusal preparations. When the second number of the formula is 75 to 85, it is used on mesial margin and when 90 to 100, it is used for distal margin (Fig. 12.11)  
For inlay or onlay preparation, 100 and 75 numbered pairs are used while 85 and 90 numbered pairs are used for amalgam preparations.
7. *Cleoid and Discoid*—They are used for removing caries and carving amalgam or wax patterns. The blades are claw like in cleoid and sharp circular in discoid (Fig. 12.12).
8. *Knives*—The blades are thin designed in various sizes and shapes. Knives are used for trimming excess filling material and contouring the surface of the restoration (Fig. 12.13).

Development of rotary cutting devices in dentistry

|      | Year                   | Device                                                                                   | Maximum speed in RPM |                        |
|------|------------------------|------------------------------------------------------------------------------------------|----------------------|------------------------|
| I.   | Ultra low speed        |                                                                                          |                      |                        |
|      | 1728                   | Finger rotated instruments                                                               | 300                  |                        |
|      | 1871                   | Foot engine                                                                              | 700                  |                        |
|      | 1874                   | Electric engine motor driven                                                             | 1000                 |                        |
| II.  | Low speed              |                                                                                          |                      |                        |
|      | 1914                   | Dental Unit (Electric motor as a power source)                                           | 5000                 | (Fig. 12.22)           |
|      | 1942                   | Diamond cutting instruments                                                              | 5000                 |                        |
|      | 1946                   | Old units converted to increase speed                                                    | 10,000               |                        |
| III. | Medium speed           |                                                                                          |                      |                        |
|      | 1947                   | High speed electric engines with Tungsten carbide burs                                   | 12,000               |                        |
|      | 1953                   | Ball bearings handpieces                                                                 | 25,000               |                        |
| IV   | High speed             |                                                                                          |                      |                        |
|      | 1955                   | High speed engine with water cooling turbine angle handpiece                             | 50,000               |                        |
|      | 1955                   | Belt-driven water cooling angle handpiece (Page-Chayes) with speed increasing slip joint | 150,000              |                        |
| V    | Ultra high speed       |                                                                                          |                      |                        |
|      | 1957                   | Air turbine angle handpiece with coolant                                                 | 2,00,000             |                        |
| VI   | Super ultra high speed |                                                                                          |                      |                        |
|      | 1960                   | Air turbine angle handpiece with coolant                                                 | 3,00,000             | (Figs 12.23 and 12.24) |
|      | 1961                   | Air turbine straight handpiece with coolant (Air motor)                                  | 25,000               |                        |
|      | 1962                   | Experimental air bearing handpiece with coolant-not used routinely                       | (800,000)            |                        |
|      | 1994                   | Contemporary air turbine handpiece with coolant                                          | 3,00,000 to 4,00,000 |                        |

## INSTRUMENT GRASPS

Correct instrument grasps are important for achieving success in operative procedures. Basic instrument grasps are:

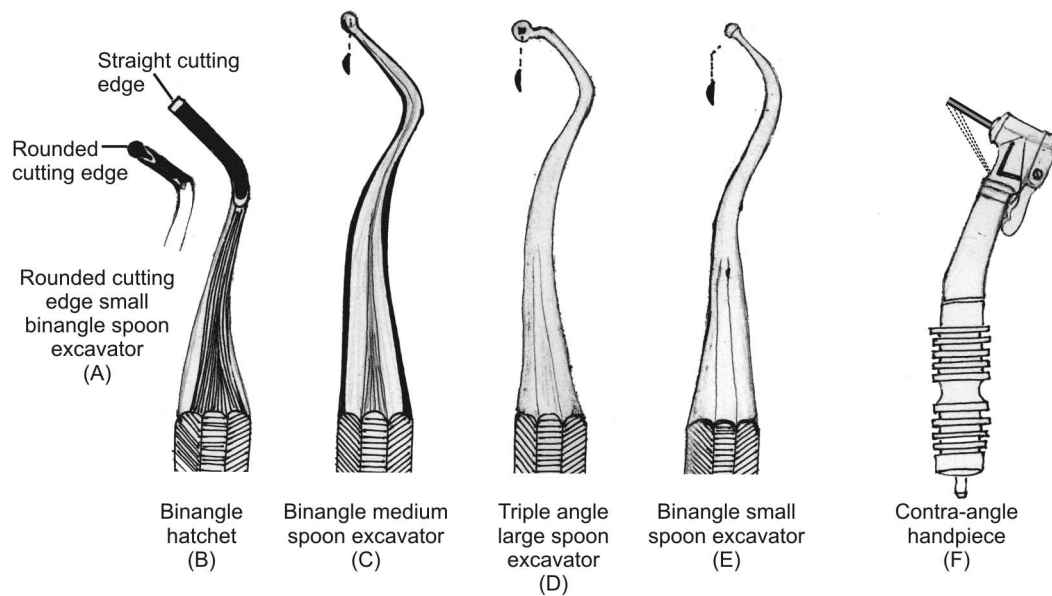
1. Modified pen grasp
2. Inverted pen grasp
3. Palm and thumb grasp
4. Modified palm and thumb grasp.

The correct grasp is selected according to the instruments being used, position of instrument being used, the operator, the area which is being operated and the specific procedure to be done.

**Modified pen grasp:** This is the most commonly used grasp. The greatest delicacy of touch is provided by this grasp. The instrument is held between the thumb and

the first and middle finger, while the tip of the ring finger and little finger are placed as a rest on a nearby tooth surface.

The grasp is similar to that as one would hold a writing pen, but not identical. The pen grasp is usually not used in holding the instruments (Fig. 12.14A). The modified pen grasp is used for holding the instrument. The pad of the middle finger should rest on the shank of the instrument. The first (index) finger is positioned above the middle finger on the same side by bending at the second joint from the fingertip. The positioning of the fingers in this manner creates a triangle of forces or tripod effect, which enhances the instrument control. It is most commonly used in mandibular teeth. In modified pen grasp the palm of the operator is facing away from the operator (Fig. 12.14B).



Figs 12.10A to E: Some commonly used hand instruments

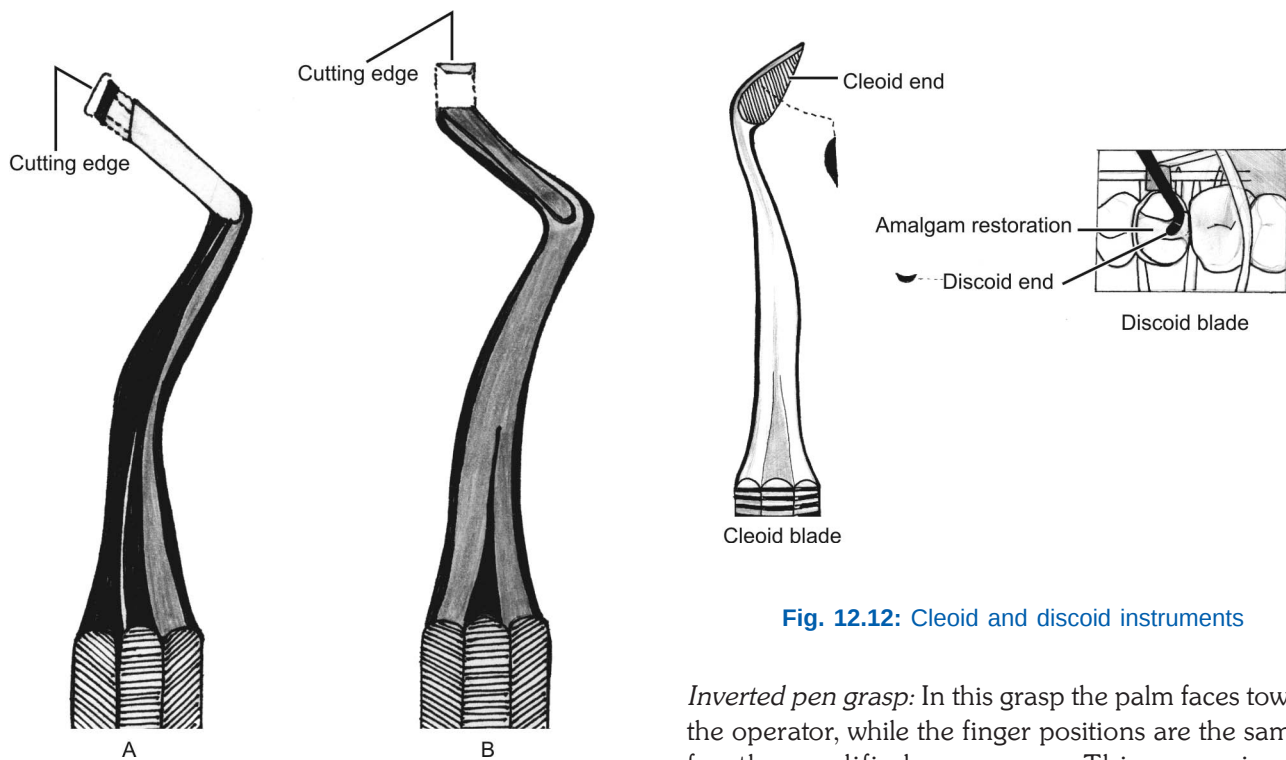
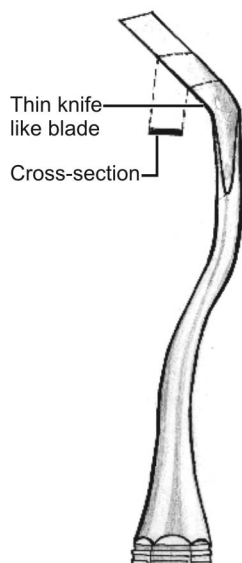


Fig. 12.11: Types of chisels with corresponding instrument formulae (A). Gingival margin trimmer (12 1/2 -100-8-14) (B). Gingival margin trimmer (12 1/2 -75-8-14)

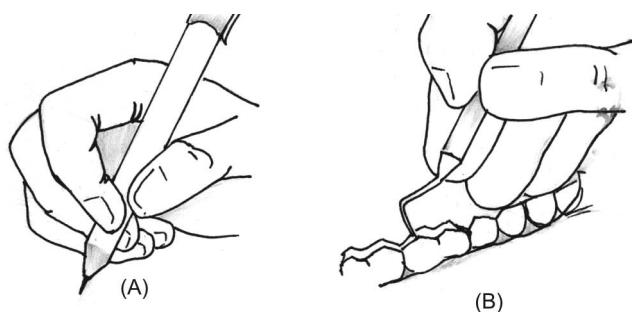
Fig. 12.12: Cleoid and discoïd instruments

*Inverted pen grasp:* In this grasp the palm faces towards the operator, while the finger positions are the same as for the modified pen grasp. This grasp is most commonly used for preparing cavity in the anterior teeth by lingual approach. The reverse or inverted pen grasp is most commonly used in maxillary teeth (Fig. 12.15).





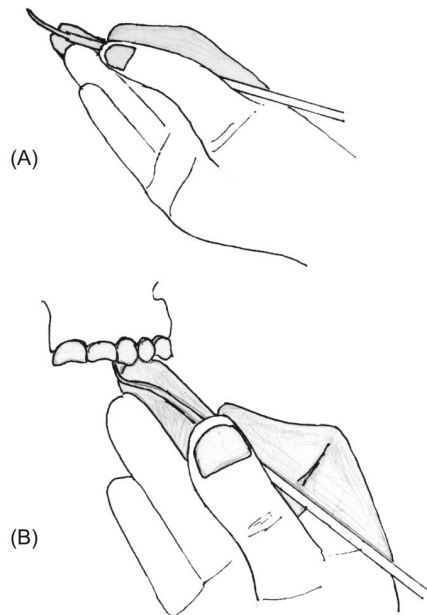
**Fig. 12.13:** Finishing knife



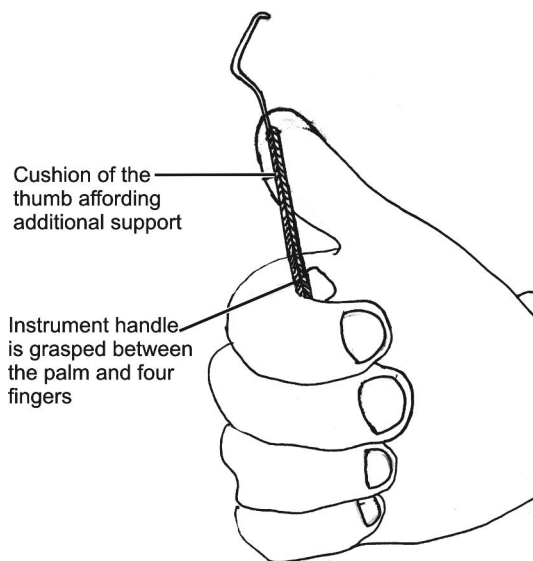
**Fig. 12.14:** Instrument grasps (A) Pen Grasp  
(B) Modified Pen Grasp

**Palm and thumb grasp:** This grasp is same as for holding the knife for peeling the skin of a big apple. The shaft of the instrument is placed on the palm of the hand and grasped by the four fingers to provide firm control, while the cushion of the thumb is free of instrument to control movements and provide rest on a nearby tooth of the same arch or on a firm and stable structure. To obtain the thrust action, with the fingers and palm the instrument is forced away from the tip of the thumb which is at the rest position. This is the grasp used for holding a handpiece while cutting incisal retention for a class III cavity in maxillary incisor (Figs 12.16 and 12.17).

**Modified palm and thumb grasp:** The instrument is held like the palm grasp but the pads of all the four fingers press the handle against the distal area of the palm as well as the pad and first joint of the thumb. This grasp



**Fig. 12.15:** The reverse or inverted pen grasp. (A). Position of fingers and hand. (B) Position of fingers and hand during application of instrument to maxillary right quadrant

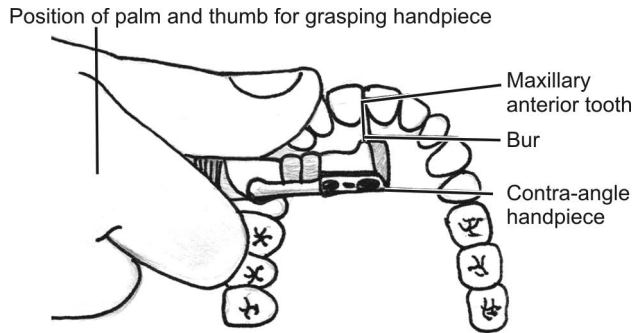


**Fig. 12.16:** Palm and thumb grasp method of holding instrument

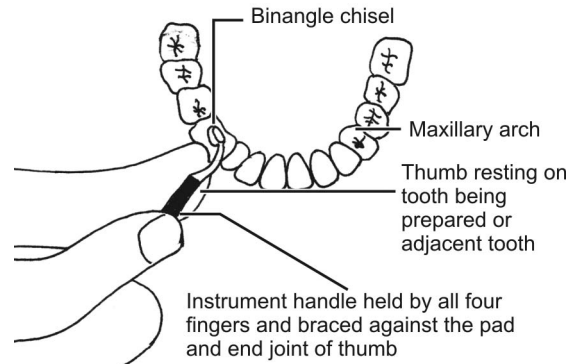
is used when it is feasible to rest the thumb on the tooth being prepared or the adjacent tooth (Fig. 12.18).

### Finger Rests

The finger rest serves to stabilize the hand and the instrument by providing a firm rest to the hand during



**Fig. 12.17:** Palm and thumb grasp of contraangle hand piece while bur tip is being applied to lingual aspect of maxillary anterior teeth

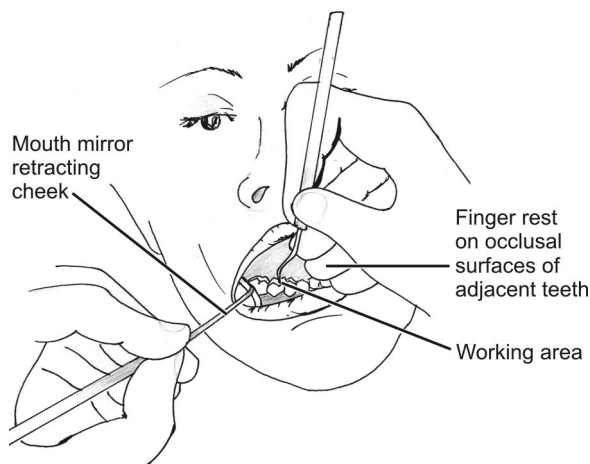


**Fig. 12.18:** Modified palm and thumb grasp

operative procedures. Finger rests may be intraoral or extraoral.

#### A. Intraoral finger rests

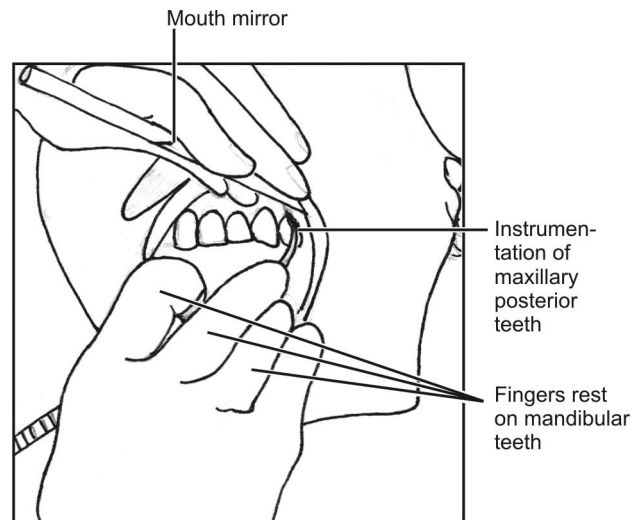
1. Conventional: In this the finger rest is just near or adjacent to the working tooth (Fig. 12.19)



**Fig. 12.19:** Intraoral conventional finger rest grasp. Finger rest is established on the occlusal surfaces of the teeth immediately adjacent to working area

2. Cross arch – In this the rest is obtained by the tooth of the opposite side but of the same arch.
3. Opposite arch – In this the rest is obtained by the tooth of the opposite arch (Fig. 12.20).
4. Finger on finger - By the index finger or thumb of non-operating hand the rest is obtained.

B. Extraoral finger rest - It is used mostly for maxillary posterior teeth.



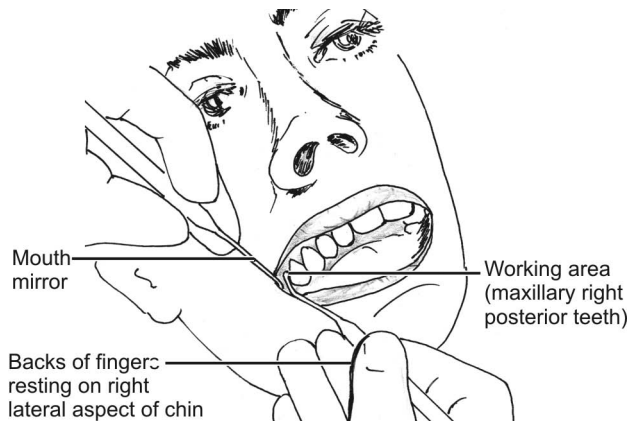
**Fig. 12.20:** Intraoral opposite arch finger rest for instrumentation of maxillary posterior teeth. Finger rest is established on mandibular teeth

*Palm up*—The rest is established by resting the back of the middle and fourth finger on the lateral aspect of the mandible on the right side of the face (Fig. 12.21).

*Palm down*—The rest is obtained by resting the front surface of the middle and fourth fingers on the lateral aspect of the mandible on the left side of the face.

### Sharpening of Hand Instruments

Hand cutting instruments with dull cutting edges are a definite hazard because they cause more pain when applied to enamel or dentin, prolong operating time, are less controllable and reduce quality and precision in cavity preparation. Therefore, resharpening of all the hand instruments for cutting is essential. For



**Fig. 12.21:** Extraoral palm up fulcrum for effective instrumentation of maxillary right posterior teeth. Fulcrum is established by resting the backs of fingers on right lateral aspect of chin

sharpening instruments, stationary sharpening stones, mechanical sharpeners and stones to be used in handpiece are used.

### AIR ABRASIVE METHOD

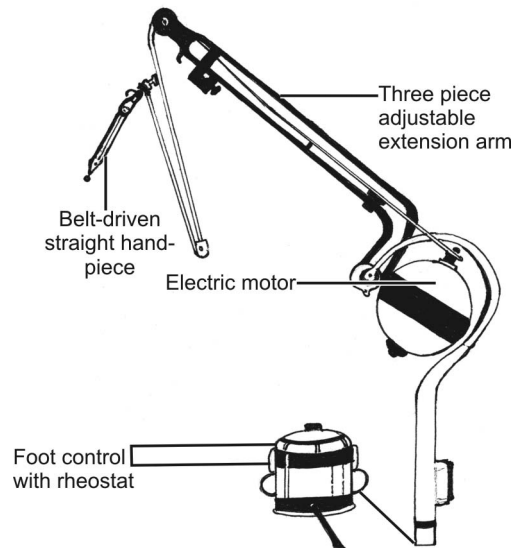
In this method the fine abrasive particles were mixed with air. This air in the form of fine 'jets' was used for cutting of the tooth structure. This method was untidy, cumbersome and very slow. The cutting was uncontrollable. Therefore, this method has been discontinued with the development of better rotary cutting instruments.

### ROTARY CUTTING INSTRUMENTS

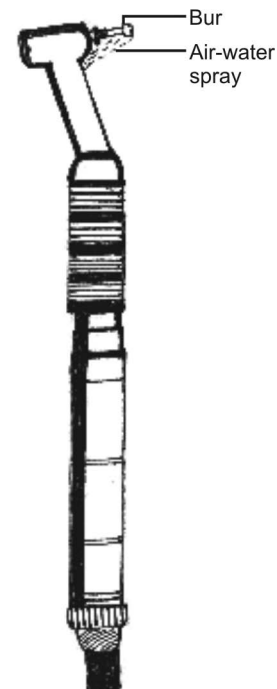
Rotary cutting instruments are those instruments which rotate on an axis to do the work of abrading and cutting on tooth structure (Figs 12.22 to 12.25)

### DEVELOPMENT OF ROTARY CUTTING INSTRUMENTS

The first rotary instruments were drill or bur heads that were twisted with the fingers for crude cutting of the tooth tissue. Drill-ring came as the modification in 1728 where seat for the drill was provided by a socket fitting against the palm and the ring was adapted to the index or middle finger. From the Singer sewing machine in

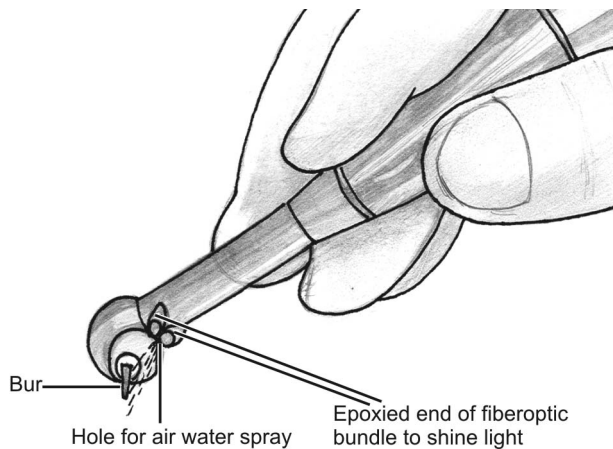


**Fig. 12.22:** Electric engine typical equipment for use of electric motor as a power source



**Fig. 12.23:** Airotor handpiece

1871, Morrison modified and adapted the dental foot engine. In 1874, electric engine came into practice. Electrical dental engine with flexible cable arm linking the handpiece was introduced in 1883. Ball bearing handpieces were developed in 1953. Air turbine angle



**Fig. 12.24:** Ventral view of airtor handpiece including fiberoptic lighting of the cutting side and port for air- water spray on to bur at cutting side



**Fig. 12.25:** Normal designation of the parts of rotary cutting instrument (Bur)

handpiece was introduced to the profession in 1957. The latest addition in the field of rotary instruments is contemporary air turbine handpiece evolved in the year 1964. Later light fiber optic was added to provide light beam at the cutting tip of the bur.

Some equipment can actually produce speed more than 5 lac RPM.

### ROTATIONAL SPEED RANGE

To measure the rotational speed of an instrument the term revolutions per minute [rpm] is used.

- Ultra low speed* (upto 1000 rpm): Now-a-days this speed is used only for finishing with abrasive disks and for drilling holes for implants in the bone.
- Low or slow speed* (1000 to 10,000 rpm): This speed is used for refinement of the preparation and finishing and polishing procedures. At low speed, cutting is ineffective, time consuming and produces vibrations of low frequency and high amplitude.
- Medium speeds* (12,000 to 25,000 rpm): The early handpieces were electric driven but the later were air driven. The air driven are more effective for cutting tooth structure and reducing perceived vibrations.
- High speeds* (50,000 to 1,50,000 rpm): The instrument has an air turbine which uses compressed air as the power source. The speed is used for tooth preparation, removing of old restorations with less pressure, vibration and heat production, and decreased operating time.
- Ultra high speed* (2,00,000 to 3,00,000 rpm): In air turbine handpieces compressed air is used.
- Super ultra high speed* (above 3,00,000 rpm): High speed air turbine. Further improvements are taking place like fiberoptic lights (Fig. 12.24).

### PROCEDURE FOR REMOVAL OF TOOTH TISSUE

Burs and abrasive points are the two most commonly used means for the removal of the tooth tissues.

**Burs**—All rotary cutting instruments that have bladed cutting heads come under the term bur. Burs are milling points and work by removing tooth hard tissue chips. Two types of burs are available: (a) carbon steel burs (b) tungsten carbide burs. Diamond tooth cutting points sometimes called as burs are correctly described as diamond abrasive points as they remove tooth structure by abrasion.

In 1891, machine-made steel burs were introduced. In steel burs, blades are milled in blank piece of metal, which is then hardened and tempered to make the steel bur harder than the tooth. Steel burs are effective in cutting dentin, while on cutting enamel, they do not last long and produce heat and vibration. In 1947, carbide burs were introduced, these burs perform better

**Table 12.1:** Standard Bur Head Sizes – Carbide and Steel (1955 to Present) Head diameters in mm

| HEAD<br>In mm             | 0.5 | 0.6  | 0.8 | 1.0 | 1.2 | 1.4 | 1.6 | 1.9 | 2.1 | 2.3 | 2.5 | 2.8 | 3.0 | 3.3 |
|---------------------------|-----|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| SHAPES                    |     |      |     |     |     |     |     |     |     |     |     |     |     |     |
| Round                     | ¼   | ½    | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  |     |
| Wheel                     |     | 11 ½ | 12  | 14  | 16  |     |     |     |     |     |     |     |     |     |
| Inverted cone             |     | 33 ½ | 34  | 35  | 36  | 37  | 38  | 39  | 40  |     |     |     |     |     |
| Plain flat fissure        |     | 55 ½ | 56  | 57  | 58  | 59  | 60  | 61  | 62  |     |     |     |     |     |
| Round crosscut            |     |      |     | 502 | 503 | 504 | 505 | 506 |     |     |     |     |     |     |
| Straight fissure crosscut |     |      | 556 | 557 | 558 | 559 | 560 | 561 | 562 | 563 |     |     |     |     |
| Tapered fissure crosscut  |     |      |     | 700 | 701 |     | 702 |     | 703 |     |     |     |     |     |
| End cutting fissure       |     |      |     | 957 | 958 | 959 |     |     |     |     |     |     |     |     |
| Round finishing           |     |      |     | A   | B   | C   | D   |     | 200 | 201 | 202 | 203 |     |     |
| Oval finishing            |     |      |     |     |     |     |     |     | 218 | 219 | 220 | 221 |     |     |
| Pear finishing            |     |      |     |     |     |     |     |     | 230 | 231 | 232 |     |     |     |
| Flame finishing           |     |      |     | 242 | 243 | 244 | 245 | 246 |     |     |     |     |     |     |

**Table 12.2:** Names and key dimensions of commonly used burs

| Shape                     | Manufacturer's<br>size number | ADA<br>size<br>number | ISO<br>size<br>number | Head<br>diameter<br>(mm) | Head<br>length<br>(mm) |
|---------------------------|-------------------------------|-----------------------|-----------------------|--------------------------|------------------------|
| Round                     | ¼                             | ¼                     | 005                   | 0.50                     | 0.40                   |
| Round                     | ½                             | ½                     | 006                   | 0.60                     | 0.48                   |
| Round                     | 2                             | 2                     | 010                   | 1.00                     | 0.80                   |
| Round                     | 4                             | 4                     | 014                   | 1.40                     | 1.10                   |
| Inverted cone             | 33S*                          | -                     | 006                   | 0.60                     | 0.45                   |
| Inverted cone             | 33 ½                          | 33 ½                  | 006                   | 0.60                     | 0.45                   |
| Tapered fissure           | 169                           | 169                   | 009                   | 0.90                     | 4.3                    |
| Elongated tapered fissure | 169L#                         | 169L                  | 009                   | 0.90                     | 5.6                    |
| Pear, normal length       | 329                           | 329                   | 007                   | 0.70                     | 0.85                   |
| Pear, normal length       | 330                           | 330                   | 008                   | 0.80                     | 1.00                   |
| Pear long length          | 245 + @                       | 330 L                 | 008                   | 0.80                     | 3.0                    |
| Tapered fissure           | 271 +                         | 171                   | 012                   | 1.20                     | 4.0                    |
| Tapered fissure           | 272 +                         | 172                   | 016                   | 1.60                     | 5.0                    |

\* Similar to the No. 33 ½ bur except that it is safe-sided end cutting only.

# Similar to the No. 169 bur except for greater head length.

+ These burs differ from the equivalent ADA size by being flat ended with rounded corners. The manufacturer's number has been changed to indicate this difference.

@ Similar to the No. 330 bur except for greater head length

than steel burs. The burs are made by powder metallurgy, where carbon, steel, 5 to 10 percent of cobalt and tungsten carbide is packed into a mold and sintered at high temperature. In most of the carbide burs the carbide head is attached to the steel shank by welding or brazing (Fig. 12.18).

## PARTS AND DESIGN OF ROTARY CUTTING INSTRUMENTS

The rotary instruments burs and abrasive points consist of three parts (1) Shank (2) Neck or shaft (3) Head (Fig. 12.25) (Tables 12.1 and 12.2).

**Design of the shank:** This part fits and accepts the rotary motion from the handpiece. There are five types of shanks. Out of these, three types straight handpiece shank (for straight handpiece of airmotor and micromotor), latch-type angle shank (for contra-angle handpieces of air motor and micromotor), and friction-grip angle handpiece shank (for airtor handpiece) are common. Straight handpiece are commonly used for extra-oral finishing and polishing of indirect restorations.

**Design of neck or shaft:** It connects the shank to the head. The function of the neck is to transmit rotational



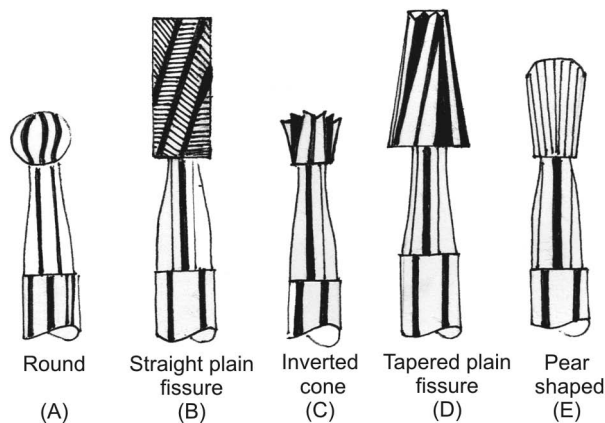
and translational forces to the head. From the shank diameter the neck normally tapers to the size of the head.

**Design of head:** It is the working part of the instrument to which cutting edges or points are attached. The shape of the head and the design of the blades classify the bur and the way to be used in cavity preparation.

### Shape of Bur Head

The basic shapes of bur head shapes are as follows (Fig. 12.26).

- Round bur:** Round bur is used for initial entry into the cavity, removal of caries, preparation of retention grooves (Fig. 12.26A).
- Straight plain or flat fissure:** Straight plain or flat fissure bur is used for extension of the cavity preparation (Fig. 12.26 B).
- Inverted cone:** The apex of the cone is directed towards the bur shank. Usually the diameter is nearly same as of the head length. Inverted cone bur is useful for providing undercuts in the cavity (Fig. 12.26C).
- Tapered plain fissure:** In tapered plain fissure bur the small end of the cone is directed away from the bur shank. This bur design is usually used for inlay and crown preparations (Fig. 12.26 D).
- Pear shaped:** In pear shaped bur there is a portion of a slightly tapered inverted cone with the small end of the cone directed towards the bur shank. It provides rounded line angles and point angles required for composites restorations (Fig. 12.26E).



**Figs 12.26 (A) to (E): Basic head shapes of dental burs**

### Design of Bur Blade

Rake face and clearance face are the two sides of the blade. Rake angle, clearance angle and edge angle are the three important angles. These angles are measured in relation to the radial line of the blade. When the rake face is ahead of the radius, the rake angle is said to be negative, chances of fracture for the cutting edge are minimized by increasing negative rake angle. Clearance angle prevents the bur edge from digging into the tooth structure. On decreasing the edge angle, clearance angle is increased. All the three angles are related to each other and cannot be varied independently of each other (Fig. 12.27).

### Abrasives

Fine abrasives smoothen and rough abrasives reduce the tooth surface by grinding. In abrasive instruments, in the matrix of soft materials, angular particles of a hard substance are held. Instead of a continuous blade, edge cutting occurs at a large number of points where individual hard particles protrude from the matrix.

Different types of abrasives are as follows:

#### Diamond

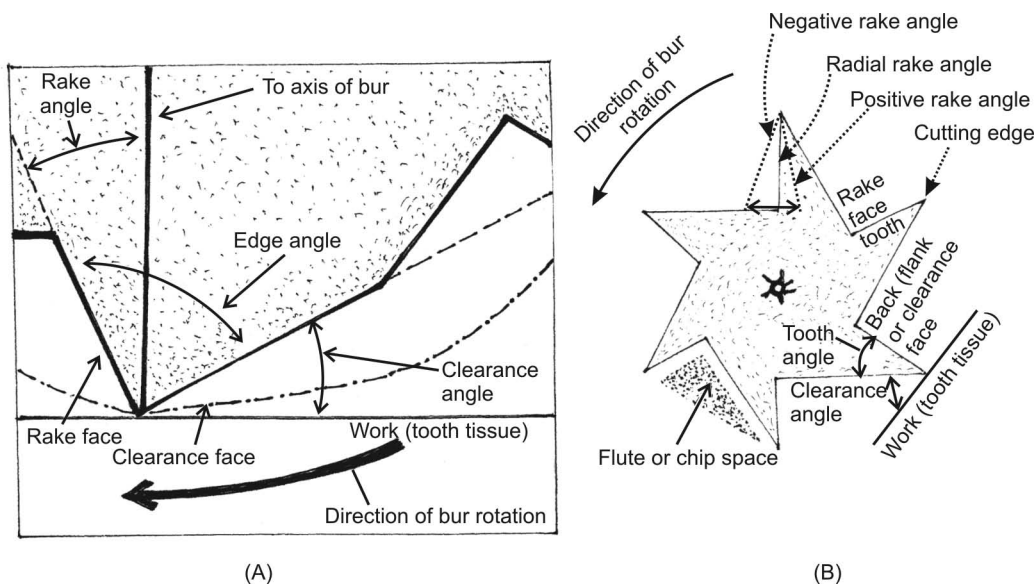
Natural or synthetic diamond is crushed to powder and then graded according to size. The particle size is characterized as coarse (150 to 125 micron), medium (125 to 88 micron), fine (87 to 60 micron) and very fine (59 to 38 micron).

#### Head Shapes and Sizes of Diamond Abrasive Points and Instruments

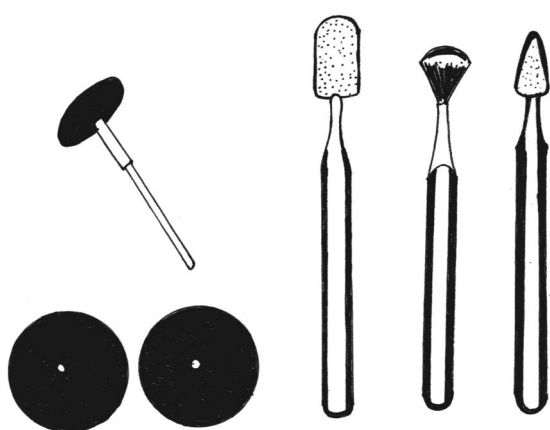
Diamond instruments are available in wide variety of shapes and sizes. More than 250 shapes and sizes are currently marketed. Because of their design with an abrasive layer over an underlying blank, the smallest diamond instrument cannot be as small as the smallest burs, but a wide range of sizes is available for each shape. Because of the lack of uniform nomenclature for diamond instruments, it is often necessary to select them by inspection to obtain desired size and shape or select them after consulting manufacturer's catalogues.

#### Carborundum Silicon Carbide

It is usually available in various shapes and is used for finishing restorations and tooth structure (Figs 12.28 and 12.29).



**Fig. 12.27:** Design of Bur blade (A). Rake angle, edge angle and clearance angle in cross-section in relation to direction of bur rotation. (B). Six-bladed tungsten carbide or steel bur in cross-section showing cutting edge, positive, negative and radial rake angles flute or chip space and bur tooth angle etc. in relation of direction of bur rotation



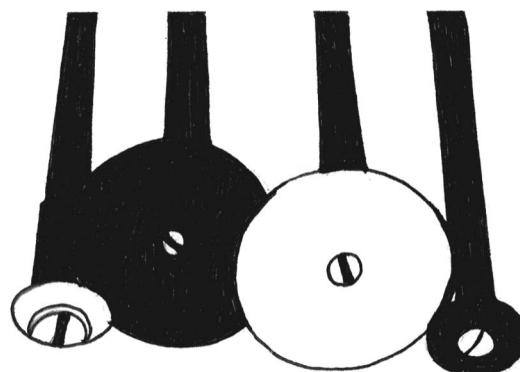
**Fig. 12.28:** Carborundum separating disk and finishing burs of various shapes

### Aluminium Oxide

It is white, fine textured and produces a fine surface. Garnet (reddish) quartz (white) are available in the form of abrasive wheels in ranges from coarse, medium and fine. These stones can be mounted or unmounted. Unmounted can be mounted on the mandrel and then used.

### Pumice

In rubber wheels and cups pumice is used as a polishing material in the laboratory and intraorally. Pumice is



**Fig. 12.29:** Carborundum disks and finishing rubber disks

produced by crushing foamed volcanic glass into thin glass flakes, to which silica and tin oxide may be added.

### Sand Paper Disks and Finishing Stones and Points

Garnet, cuttlefish or different abrasives are glued together to give different sizes and shapes of finishing stones and to paper with shellac to produce disks. They are used for final finishing and polishing (Figs 12.30 and 12.31).

### Crocus Disks

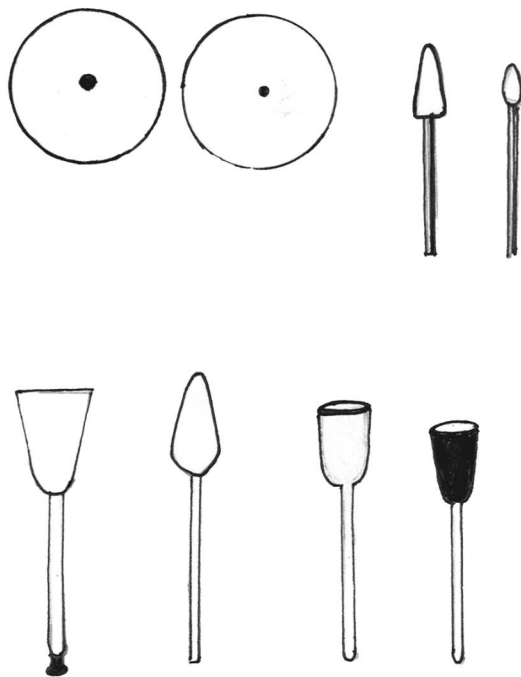
In crocus disks iron oxide is charged over paper disks. After using the sand paper abrasives, the margins of the casting are smoothed with crocus disks.

### Pulpal Precautions

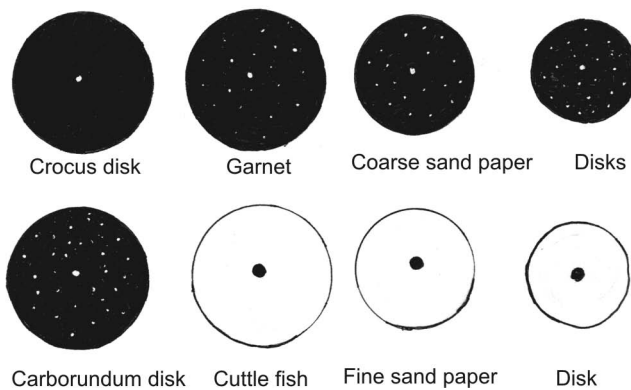
Trauma to the pulp during cavity preparation may occur due to mechanical vibration, improper cavity form and heat generation during cutting. Tissue removal should be done only with adequate finger rests and good visibility of the operating field.

Burs and diamond instruments if they are dull or plugged with debris do not cut efficiently and produce more heat. Spray of air-water as coolant at the rotary instrument can adequately control the heat rise and also prevent plugging with debris. If air is used alone, it unnecessarily desiccates the dentin and damages the odontoblast, so it is not effective and harmful and should not be used alone. Air-water spray not only cools but also moistens the tissues, lubricates and cleans the rotary cutting instruments and also cleans the operating site.

For the maximum safety and comfort of the patient, the air-water coolant should be isothermal to body temperature, otherwise during extreme cold climate or due to excessive cooling by air conditioning sensitivity to cutting may result due to excessive cooling rather than heating.



**Fig. 12.30:** Finishing and polishing instruments



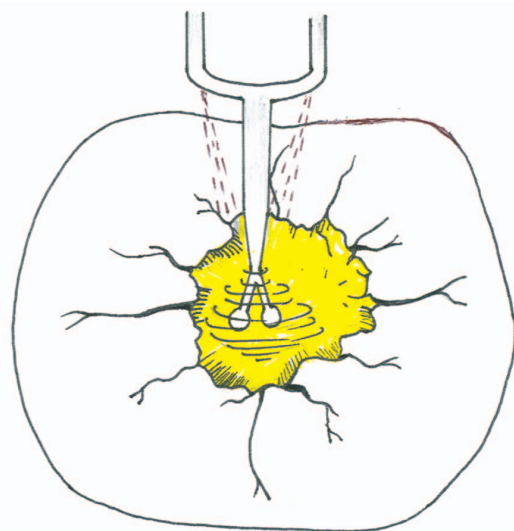
**Fig. 12.31:** Different types of abrasive disks

### HAZARDS AND PRECAUTIONS WITH ULTRASPEED CUTTING INSTRUMENTS

The hazards associated with ultraspeed cutting instruments can be avoided or reduced by taking the following precautions.

### Condition of Burs and Rotary Instruments

All the burs and rotary instruments should be perfectly centric. Even a slightly eccentric bur can destructively damage the surrounding dental tissues and the handpiece (Fig. 12.32).



**Fig. 12.32:** A slightly eccentric bur can damage the surrounding dental tissues

### Other Soft Tissue Precautions

Lacerations may occur in the lips, tongue, cheeks and floor of the mouth if proper precautions are not taken. Good visibility of the operative field is very important. If good vision and proper access is not there, handpiece should never be operated. Isolation of the operating site by the rubber dam is helpful. If rubber dam is not used, cotton roll and evacuating tip contribute to good visibility and improved access.

During cutting procedures, sudden movement by the patient due to gagging, swallowing or coughing can result in soft tissue injury. If soft tissue injury takes place, hemorrhage should be controlled with pressure pack and local application of hemostatic agent with absorbent cotton gauze. If sharp cut is there fine stitching should be done. While removing the rotating air turbine handpiece, wait for the instrument to stop, because the rotating instrument does not stop immediately after releasing the foot control.

### Ear Precautions

In comparison to conventional rotary instruments air turbine handpieces have the problem of high noise level and frequency of vibration. The noise emitted by air turbine handpieces ranges from 75 to 100 decibels and the frequency is above 2000 cycles per second. With wear of bearing, noise is increased. When the noise level reaches 85 decibels with frequency ranging above 5000 cycles per second, protective measures are recommended. In protective measures, sound proofing of the room with sound absorbing materials can be done, or ear plugs may be used after considering their drawbacks.

### Inhalation Precautions

By cutting tooth structure and restorative materials by air turbine, aerosols and vapors are produced. These particles when inadvertently inhaled by the patient or by the dental personnel may produce alveolar (lung) irritation, tissue reactions or may transfer infectious diseases. Oral inhalation of aerosols and vapors by the patient can be avoided by the use of rubber dam. For prevention disposable masks must be used by dental office personnel.

### Eye Precautions

When tooth tissue, calculus or old restorations are removed from the patient's mouth at high speeds, to

protect the eyes from flying particles, bacteria and other debris, glasses should be worn by the patient and the dental personnel. While using laser equipment or light using materials, either plastic shields should be used or protective eyeglasses should be worn by every body in the room.

*Use of coolants:* Coolants with air and water running at high speed should always be used with high speeds.

Von Fraunhofer et al concluded that there is increased cutting efficiency at higher coolant flow rates.

## LASER FOR CARIES REMOVAL AND TOOTH PREPARATION

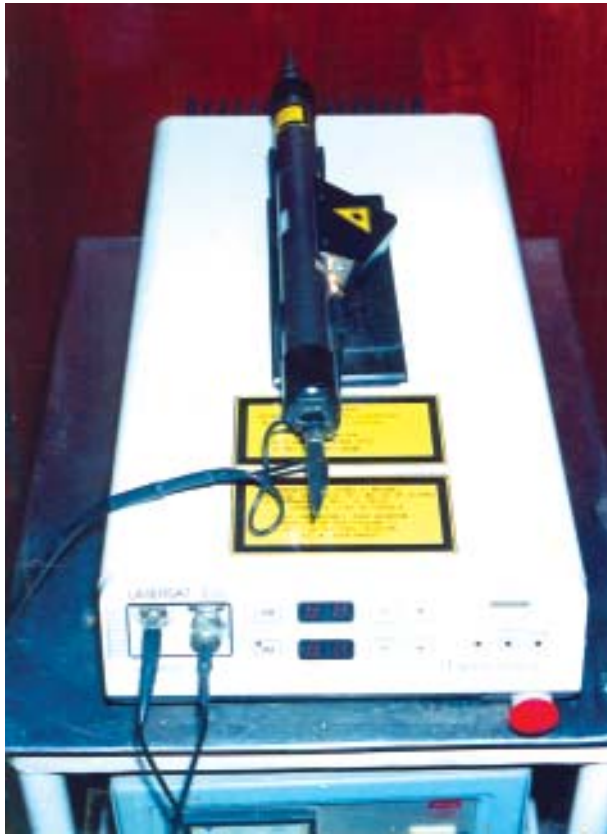
Laser is an acronym for "light amplification by stimulated emission of radiation." LASER produces beams of coherent and very high intensity light. LASER systems are capable of modifying hard dental tissues by recrystallization and vaporization. The effects of laser beam are controlled by its power and the extent of its absorption. The dental laser mostly produces photothermal effect with the ablation of soft or hard tissue (Figs 12.33 and 12.34) (Table 12.3).

**Table 12.3:** The effects on the dental tissues observed at various temperatures produced by various types of lasers

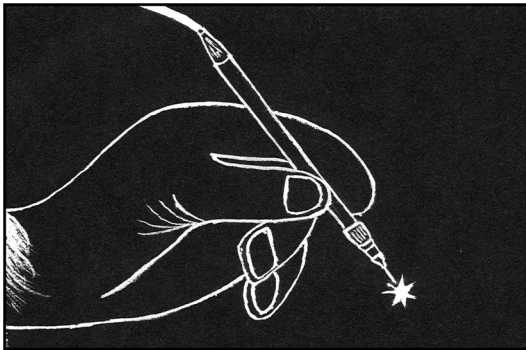
| S. No. | Temperature in degree centigrade | Changes produced in dental tissues                                                                                |
|--------|----------------------------------|-------------------------------------------------------------------------------------------------------------------|
| 1.     | Below 100                        | 1. Denature proteins<br>2. Produce hemolysis<br>3. Cause coagulation and shrinkage                                |
| 2.     | Between 100 to 400               | 1. Water in soft and hard tissues boils and produces explosive expansion.                                         |
| 3.     | Between 400 to 1400              | 1. Carbonization of organic materials is completed<br>2. Beginning of changes in inorganic material takes place   |
| 4.     | At above 1400                    | 1. Changes in the chemistry of inorganic constituents take place.<br>2. They may melt, recrystallize and vaporize |

The actual temperature and the tissue changes occurring also depend on the matching of the composition of the tissue with the type of the laser. If the laser and the tissue are well matched then more changes occur at low temperature. Infrared laser match with the enamel, hence, energy is absorbed very rapidly.





**Fig. 12.33:** Laser device (Courtesy Deptt. of Periodontics, UPGUDS Lucknow)

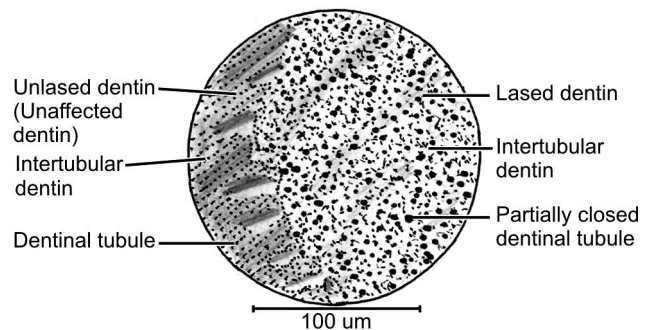


**Fig. 12.34:** Nd:YAG laser probe-laser beam emanating out of probe tip

This results in melting and recrystallization of enamel even at low energy densities for short duration. Vaporization with drilling or cutting of enamel surface takes place with high energy densities and/or for longer duration. In dentin the same effects occur at much lower energy densities. Most of the dentinal tubules obliterate

and the remaining few become prominent and more distinct (Fig. 12.35). Dentin is lasered to seal the dentinal tubules. That lasered dentin assists in bonding with restorative materials has not yet been definitely proved.

Erbium hard tissue lasers have the capability to remove enamel, dentin, caries, cementum, and bone in addition to cutting soft tissue. The ability of hard tissue lasers to reduce or eliminate (a) Vibrations, (b) the audible whine of drills, (c) microfractures, and (d) some of the discomfort and fear commonly associate with high speed handpieces. In addition, these lasers can be used with a reduced amount of local anesthetic for many procedures. Erbium lasers can be used for (a) all classes of cavity preparations (b) removing soft tissue, (c) disinfection of endodontic canals, (d) removal of bone and the removal of calculus.



**Fig. 12.35:** Lased area of dentin by Nd: YAG laser showing physical changes produced by a single pulse, surrounded by unlased dentin.

Excessive heat must be avoided to protect the pulp. Now-a-days the laser unit for use in dental practice is not cost effective as its use is very limited. Lasers are used for soft tissue application or for modification of the surface of the hard tissues to obliterate pits and fissures. Lasers are not used for tooth preparation near the pulp as they will generate high heat which will damage the pulp. Hence in near future, airtor handpiece will not be replaced by laser for routine use. Only one commercial Ho: YAG laser equipment has been approved by the Food and Drug Administration of USA (FDA) for only use on hard tissues of deciduous teeth. In near future FDA may sanction more laser applications.



## PRECAUTIONS FOR USE OF LASER

1. The door of the room must be closed where laser is being used.
2. Outside the room proper signs showing the use of laser should be displayed where lasers are being used.
3. Laser if inadvertently reflected to eye will damage the eyesight. Hence, eyes of the patient, operator and the assistants must be properly protected.

Evans et al reported that when Erbium: YAG Laser is used for endodontic access in all-ceramic crowns, diamond and tungsten burs cause similar rates of edge chipping, microcracks, and fractures. They did not recommend cavity preparation by Erbium: YAG laser and reported that there is very little advantage of the Erbium: YAG laser over conventional dental handpieces for cavity preparation. They reported problems with accessing the caries, lack of tactile feedback, and difficulties in preparing undercut areas. By laser usually fifty percent of tooth preparation is done and to complete it conventional instruments are needed. Many of the problems of performance with the dental laser for cavity preparation will be difficult to solve.

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# 13

## *Matrices, Retainers and Wedges (Separators)*

Teeth and periodontium are designed in such a manner that they mutually significantly contribute to their own health and support. They are complimentary to each other. Proper form and alignment of teeth protect periodontium. During mastication the contours of teeth as a unit protect the periodontium. A breach in the continuity of contacts of teeth gives rise to diseases of periodontium resulting in loss of teeth.

To buildup ideal contact, a knowledge of ideal tooth form of interproximal area is essential which in brief is as follows.

1. Interproximal embrasures are extending on all the four sides with definite shape around each contact area. Four embrasures are occlusal, lingual, gingival and facial (buccal/labial).
2. Anterior teeth have marble contacts with less pronounced embrasures than posteriors having ball to ball contact.
3. There is a perfect triangular interproximal space between the adjacent teeth. The apex of the triangle is the contact area. This triangle gradually widens out in all the four directions, occlusal, lingual, gingival and facial (buccal/labial). The apex is always at the contact area and base towards the outer surface.
4. The base of the triangle of interproximal space is at alveolar border, while apex is a contact area.

If proximal and contact areas are not properly restored they may cause the following important damages.

- a. Food impaction leading to recurrent caries.
- b. Injury to the periodontium
- c. Displacement of teeth
- d. Disturbed balanced occlusion and intercuspatal relations
- e. Rotation and migration of teeth.

Restoration of a tooth requires great clinical acumen so as to reproduce the original contours and contacts of

the tooth. In case of large missing wall of the tooth, support has to be provided while placing and condensing the restorative material. Usually a metallic strip serves this function and is known as the matrix band. Matrix band which forms the temporary walls is held in its place by means of a matrix band retainer which may be a mechanical device, floss, wire, thread or impression materials, etc.

Matrix band should extend 2 mm above the marginal ridge height and 1 mm below gingival margin of the cavity. Matrices range in width from 6.35 mm (1/4") to 9.525 mm (3/8") for permanent teeth and 3.175 mm (1/8") to 7.9375 mm (5/16") for deciduous teeth. Their thickness may be 0.0381 mm (0.0015") to 0.0508 mm (0.002"). ("= inch).

### **REQUIREMENTS OF A MATRIX BAND**

1. *Rigidity*: The matrix band should be rigid enough to withstand the condensation pressure applied during introduction of restoration in the plastic state, and maintain its shape during hardening.
2. *Versatility*: The matrix band should be able to conform to almost any size and shape of tooth.
3. *Comfortable to use*: The band should not cause any difficulty to the patient, or hindrance to the operator during condensation. It should displace the gingiva (without injuring) and rubber dam for ease in working.
4. *Height and contour*: The matrix band should not extend more than 2 mm beyond the occluso-gingival height of the crown of tooth. This facilitates vision and speeds up working. The matrix band helps in formation of a physiologic proximal contact relationship.
5. *Application*: The matrix band should be such that it can be applied and removed easily. It should be easy to sterilize.

## CLASSIFICATION

- A. Depending upon their method of retention they may be classified as follows:
  - i. Mechanically retained, e.g. Ivory matrix retainers no.1 and 8, Tofflemire Universal dental matrix band retainer
  - ii. Self-retained, e.g. copper or stainless steel bands.
- B. On the basis of transparency they are classified as
  - i. Transparent matrices, e.g. cellophane, celluloid
  - ii. Non-transparent matrices, e.g. stainless steel.

## TYPES OF MATRICES AND RETAINERS

Types of matrices and retainers used for various cavities are as follows.

| Types of cavities                                                                            | Matrices and retainers                                                                                                                                                                                                                                                              |
|----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| For class II cavities                                                                        |                                                                                                                                                                                                                                                                                     |
| Class II (unilateral) DO or MO                                                               | - Ivory matrix number 1<br>Nystrom's retainer                                                                                                                                                                                                                                       |
| Class II Mesio-occluso-distal, (MOD)                                                         | - Ivory matrix number 8<br>- Tofflemire matrix<br>- Steele's Siqveland self-adjusting matrix<br>- Anatomical matrix band<br>- [Copper or aluminium bands or stainless steel bands]<br>- 'T' shaped matrix band<br>- Retainerless automatrix<br>- Retainerless walser filling matrix |
| For Class III- cavities                                                                      | - 'S' shaped matrix band<br>- Plastic matrix strips<br>- Mylar strips                                                                                                                                                                                                               |
| For Class IV- cavities                                                                       |                                                                                                                                                                                                                                                                                     |
| Inciso-proximal (incisal corner)                                                             | - Plastic strips<br>- Aluminium foil<br>- Transparent crown form<br>- Anatomic matrix                                                                                                                                                                                               |
| For Class V, VI and VII cavities                                                             | - Custom made plastic matrix                                                                                                                                                                                                                                                        |
| For direct tooth colored and all other complex, complicated preparations and fractured teeth | - Plastic matrices<br>- Anatomic matrices<br>- Aluminium or Copper collars<br>- Transparent plastic crown forms<br>- Transparent plastic partial crown forms                                                                                                                        |

## MATRIX BANDS, MECHANICAL RETAINERS (HOLDERS) AND MATRICES FOR CLASS II, MOD AND COMPLEX CAVITY PREPARATION

Mostly the matrix bands are held in position by means of the retainers. Mechanical retainers are as follows.

### Ivory Matrix Holder (Retainer) No. 1

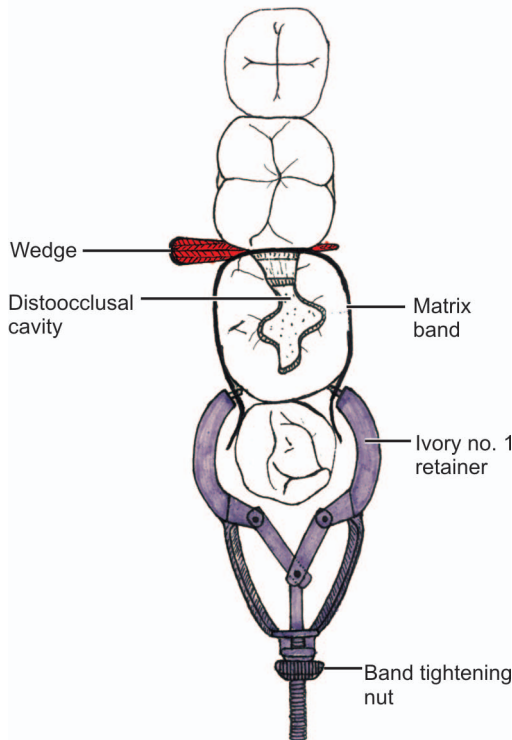
This is most commonly used matrix band holder for MO and DO cavities. This matrix band holder is used to hold the matrix band to provide missing portion of the wall for the proximal surface. The matrix holder has a claw at one end with two flat semicircle arms. Each arm has a pointed projection at the end. The two pointed projections are facing each other. On the other end of the matrix band holder there is a nut over the fine threaded rod. When this nut is tightened the ends of both the claws having pointed projections (facing each other) come closer to each other. The band of appropriate size is selected. In the middle of the band one margin is slightly projected. This projected margin of the band is kept towards the gingiva on the cavity side while the matrix band is fitted around the tooth. The free ends of the matrix band are kept on the non-cavity side of the tooth. The two sharp points of the claw are engaged in the two appropriate holes one on each half of the matrix band. Keeping the matrix band around the tooth the screw of the retainer which is kept on non-cavity side of the tooth is tightened so that the projected margin of the matrix band provides wall to the gingival seat of the cavity and the matrix completely provides the missing part of the proximal wall. The screw is gradually tightened till the matrix band perfectly fits around the tooth. The proximal cavity side of the matrix band is further tightly adapted to the outer surface of the tooth with the help of a wedge (Fig. 13.1).

### Matrix Band

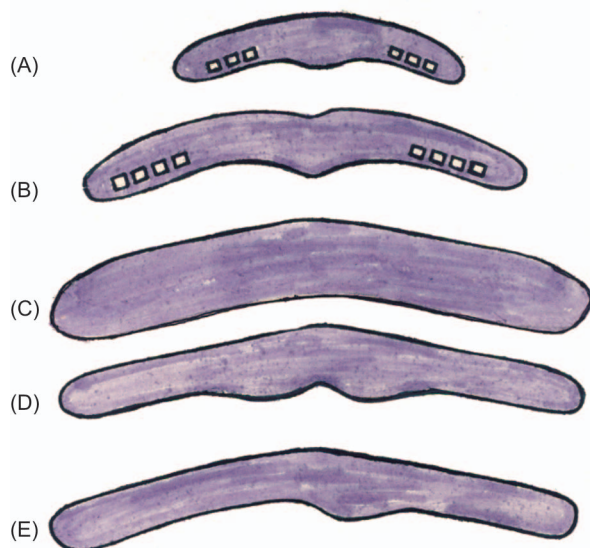
Matrices of various sizes and shapes for various retainers are available to suit all types of cavity preparations of all the teeth (Fig. 13.2).

### Ivory Matrix Band Retainer No. 8

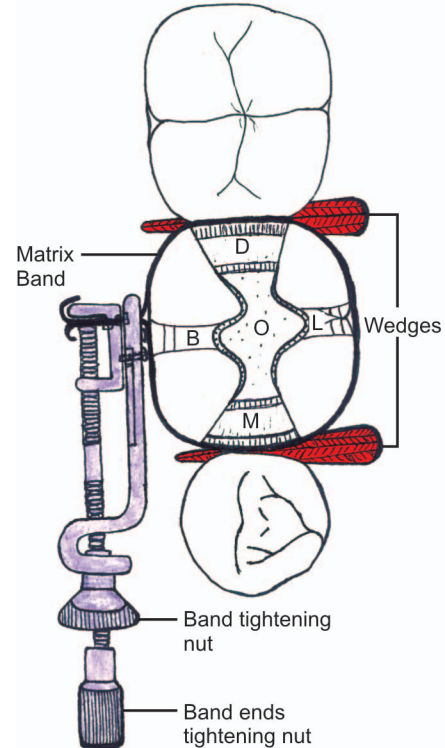
Ivory matrix band retainer is used to hold the matrix band to provide missing part of the walls on both proximal



**Fig. 13.1:** Ivory no.1 retainer and contoured matrix band is placed on disto-occlusal cavity of mandibular first molar



**Fig. 13.2:** Matrices for various retainers matrix band for Ivory no.1 retainer, (A). For premolar and deciduous molar, (B). For permanent molar. Matrix bands for Tofflemire and Steele's Siqueland matrix retainers, (C). Uncontoured (D). Contoured for mesio-occluso-distal (MOD) cavity (E). Contoured for MO or DO cavity



**Fig. 13.3:** Ivory matrix band retainer no.8 and contoured circumferential matrix band is placed on MODBL cavity of mandibular first molar with wedges on proximal sides

sides (MOD cavity) and class II compound cavities having missing walls on more than two surfaces on posterior teeth (MOB, MOL, DOB, DOL, MODL, MODB, and MODBL). This retainer provides missing walls by encircling entire crown of the tooth. The matrix band is made up of thin sheet of metal so that it can pass through the contact area of the uncut proximal side of the tooth (Fig. 13.3).

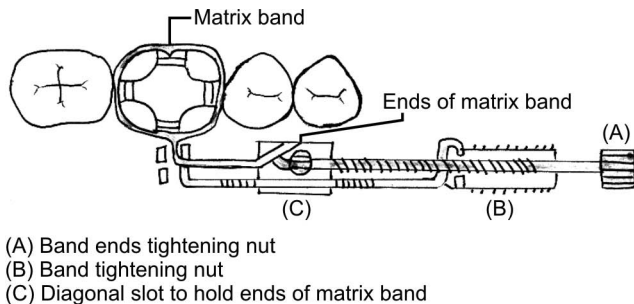
### Tofflemire Universal Matrix Band Retainer

It was designed by Dr BF Tofflemire. The word 'universal' has been added with its name because it can be used in all types of cavities of posterior teeth. This is used mainly due to its advantage of providing all the four walls and easy application and removal. The matrix band (flat or precontoured) is fitted onto the retainer after the screw is turned and the slot is about 6.35 mm (1/4 inch) from the inner end of the retainer. The band is fitted loosely over the tooth making sure that the narrow edge is placed gingivally and the wider edge is placed occlusally. The height of the band is then checked and trimmed.

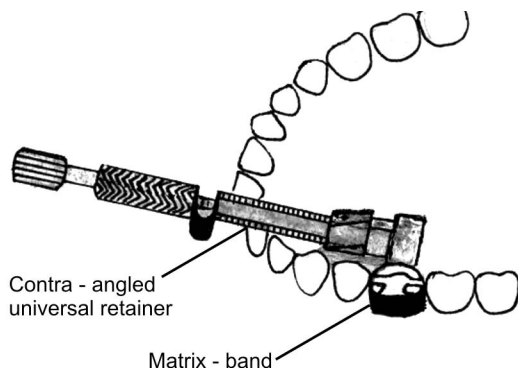


## 142 Textbook of Operative Dentistry

Thereafter, band is tightened in position by means of the screw. The retainer is usually placed in the buccal vestibule, parallel to the occlusal surface (Fig. 13.4). However, in cases of sulcus being shallow or extensive buccal caries, a contraangle retainer may be used which is placed lingually (Fig. 13.5).



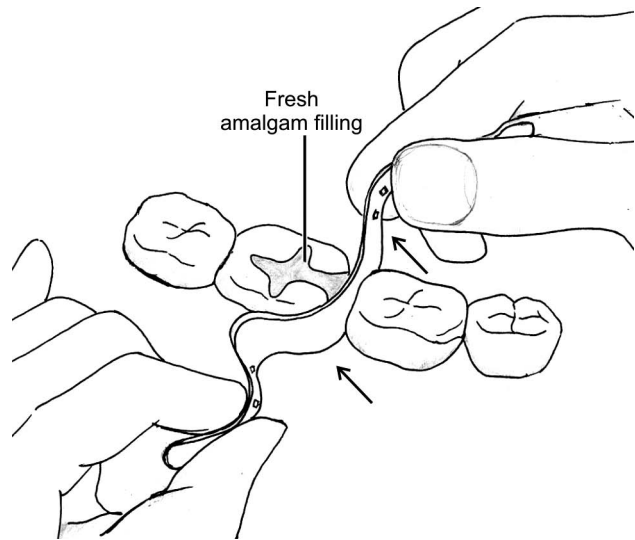
**Fig. 13.4:** Straight Tofflemire universal retainer and contoured circumferential matrix band is placed on MODBL cavity of mandibular first molar with wedges on proximal sides



**Fig. 13.5:** Contra-angled Tofflemire universal retainer positioned on lingual surface of tooth

The trimmed wedge (8 to 12 mm long) is then inserted usually from the buccal side which is wider and more convenient. This helps in the formation of (a) favorable tooth contour, (b) tight contact between tooth and the matrix band and (c) promoting stability. Sometimes two wedges may have to be used in one proximal space. The cavity and the surrounding area should be inspected to see whether any rubber dam material or soft tissues is not getting impinged. Any varnish/liner should be applied before placing the band. After condensation and initial hardening of the restorative material, the screw is loosened so as to loosen and unlock the band. The retainer is first removed. The band is removed next, by a slow

linguo-occlusal motion with the help of four fingers, two of each hand on either side rather than an occlusal jerk (Fig. 13.6).



**Fig.13.6:** Removal of the matrix band in linguo-occlusal direction (arrows) with the help of four fingers, two of each hand on either side to avoid fracture of freshly filled amalgam filling

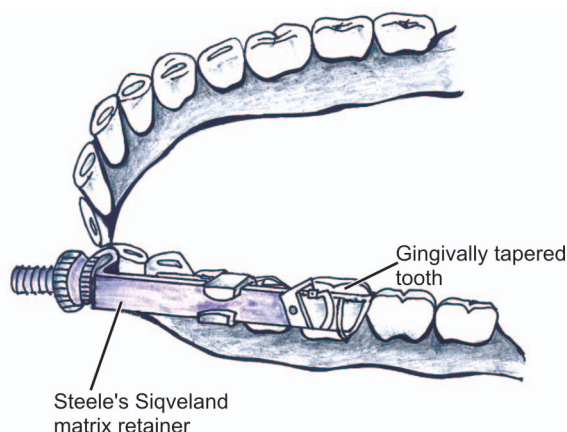
Various types of bands are available for different retainers. The number 1 band is indicated in unilateral class II cavities. The band engages the tooth at the embrasure (Figs 13.1 and 13.2).

### Steele's Siqueland Self-adjusting Matrix Holder for Tapering Teeth

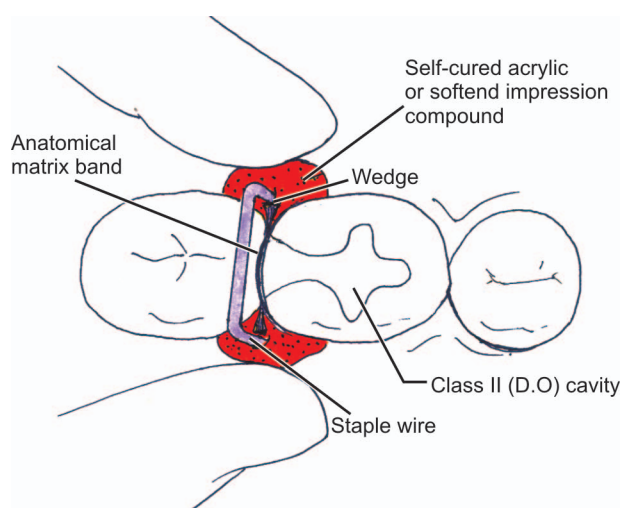
When there is a great difference between the diameters of the cervical one-third and occlusal one-third of the tooth a special type of the matrix band holder is required which can give two different diameters at the two borders of the matrix band. In such teeth usually occlusal diameter is more than cervical diameter. Anatomic adaptation of the matrix band is possible due to Steele's siqueland self-adjusting matrix holder without the help of wedges, although additional reinforcement in the form of 'wedges' at the cervical area will ensure better contour adaptation. It is based on the principle of a movable slide which holds and tightens the band in the required position (Fig. 13.7).

The number 8 band surrounds the crown of the tooth and is thus indicated for all types of compound and complex cavities in posterior teeth.





**Fig. 13.7:** Steele's Siqueland matrix band retainer suitable for tapering teeth



**Fig. 13.8:** Anatomical matrix buccally and lingually placed self-cure acrylic or softened impression compound supports are held with thumb and forefinger during hardening. To hold buccal and lingual pieces of impression compound in place, a heated staple is inserted in both of them from occlusal side

### Nystrom's Matrix Band Retainer

The shape of the slot maintains a 20 to 30 degree inclination of the retainer with the band. This prevents any trauma to the soft tissues. The narrowest part of the slot is kept towards gingiva. To prevent injury to the gingiva an angulation of the edge is made.

### RETAINERLESS MATRIX BAND

These are indicated in tilted and partially erupted teeth and also in patients who cannot tolerate retainers. The

following are important retainerless matrix bands which are commonly used.

### Anatomical Matrix Band

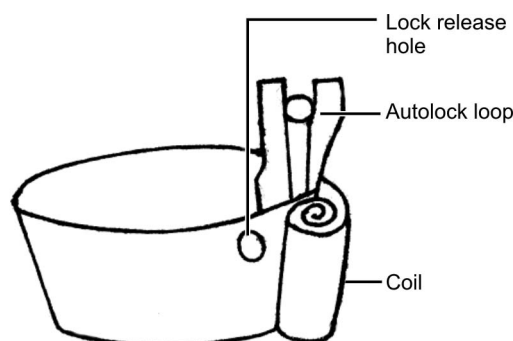
The stainless steel matrix bands 0.0029 to 0.0058 mm thick and about 3.175 mm (1/8") wide are adapted over the tooth or on cast of the tooth with one healthy tooth on either side. Pliers are used to contour the band. Precontoured anatomic matrix band is placed on cavity side. Wedges are then inserted to facilitate adaptation to surface of the tooth. Buccal and lingual embrasures are sealed by means of two selfcure acrylic or softened impression compound cones. The two cones of impression compound are further stabilized by inserting a heated wire staple. After filling the cavity the wire is cut away, wedge and compound or acrylic are removed and band pulled towards the facial surface in an angular direction.

### Retainerless Automatrix Band

This matrix comes in different sizes, are pre-formed and disposable. The matrix is fitted over the tooth with the clip on the buccal aspect. A mechanical device (a ratchet) is used to tighten the band and after condensation of filling material the band is cut away by means of cutting pliers. It is useful in patients who cannot tolerate retainers or who have partially erupted teeth (Fig.13.9).

### T-Shaped Matrix Band

Preformed brass, copper or stainless steel matrix bands are used with the long arm of the T surrounding the tooth and overlapping the short arm of the T. Wedges and impression compound may be used to provide stability.



**Fig. 13.9:** Retainerless automatrix band

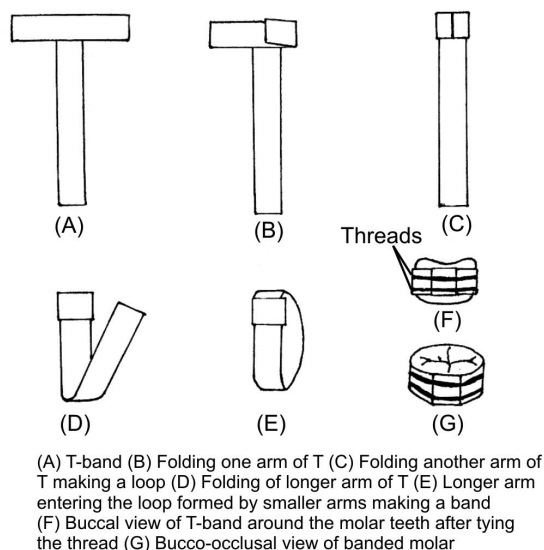


Fig. 13.10: Use of T-Band

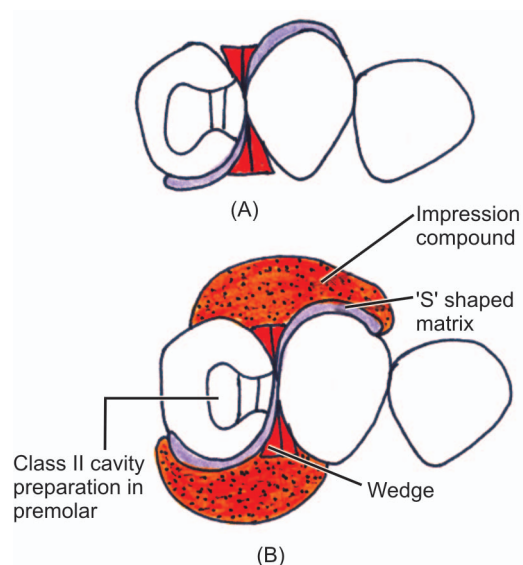


Fig. 13.11: Use of 'S' shaped matrix for class II preparation (A) Matrix and wedge in position (B) Reinforcement with impression compound

### S-Shaped Matrix Band

This is ideally used for restoring distal part of canine and premolar. A normal stainless steel matrix band is taken and shaped like 'S' by means of a mouth mirror handle. The contoured strip is placed interproximally over the facial surface of tooth and lingual surface of bicuspid (in

cases for lingual approach preparation) wedge and impression compound are used to provide stability (Fig. 13.11).

### Full Circle or Ring Bands

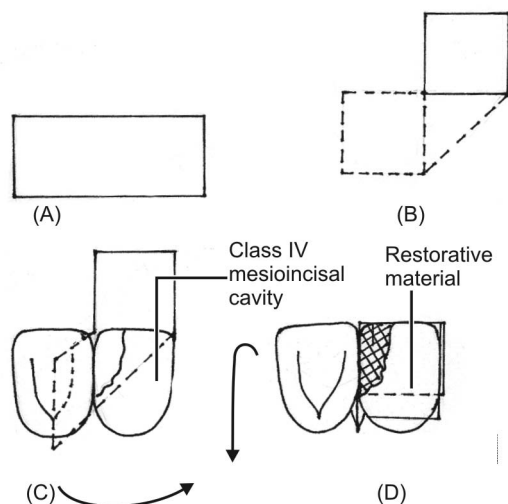
For mesio-occlusodistal compound cavities and complex cavities assorted copper or stainless steel full circle or ring bands ranging in size from 1 to 20 are also used. Once the proper size is selected it can be contoured using pliers and trimmed by cutting pliers and finished by finishing stones, after it has been softened by heating to a red hot state and quenching in water. Proximal contact of the band may be thinned using a small round fine grinding stone. Wedges may be used to stabilize the band. After condensation is complete, the band can be cut by means of a bur at the same or the next day. Sometimes stainless steel bands made according to tooth size may also be used if spot-welding facility is at hand.

### Matrices for Class III Direct Tooth Colored Restorations

1. *Plastic matrix strip*: These are transparent matrix strips. Celluloid (Cellulose nitrate) strips are used for silicate cements and cellophane (Cellulose acetate) strips are used for resins.
2. *Mylar strips*: Mylar strip may be used for composite and silicate restorations. The matrix strip (plastic/mylar) is burnished over the end of a steel instrument, e.g. a tweezer handle, to produce a 'belly' in the strip. The curvature that is formed allows for reproduction of proper contour and contact of the natural tooth (Fig. 13.12).

### Matrices for Class IV Direct Tooth Colored Restoration

1. *Plastic strip*: For inciso-proximal cavities, the strip is folded in 'L-Shape'. The matrix is measured and cut so that one side is as wide as the length of the tooth and the other side is as wide as the width of the tooth. A wedge is used to help in adaptation of the strip. The angle formed when the strip is folded should approximate the tooth corner and support the matrix on the lingual surface (which is held by forefinger of the left hand). The cavity is filled to slight excess and one end of the strip is brought across the proximal surface of the filled tooth. The other end of the strip



**Fig. 13.12:** Celluloid strip matrix-Dotted lined strip is kept on labial side and continuous lined strip is kept on lingual side to hold the restorative material firmly in place. (A) The matrix is folded at 90° forming (B) The L shaped matrix (C) Matrix is folded to form the proper angle and adapted lingually (D) After holding matrix firmly and tightly on labial side the cavity is filled with the restorative material and the matrix strip is folded on lingual side and angle of restoration is well contoured. The celluloid strip is removed after the restorative material has become hard

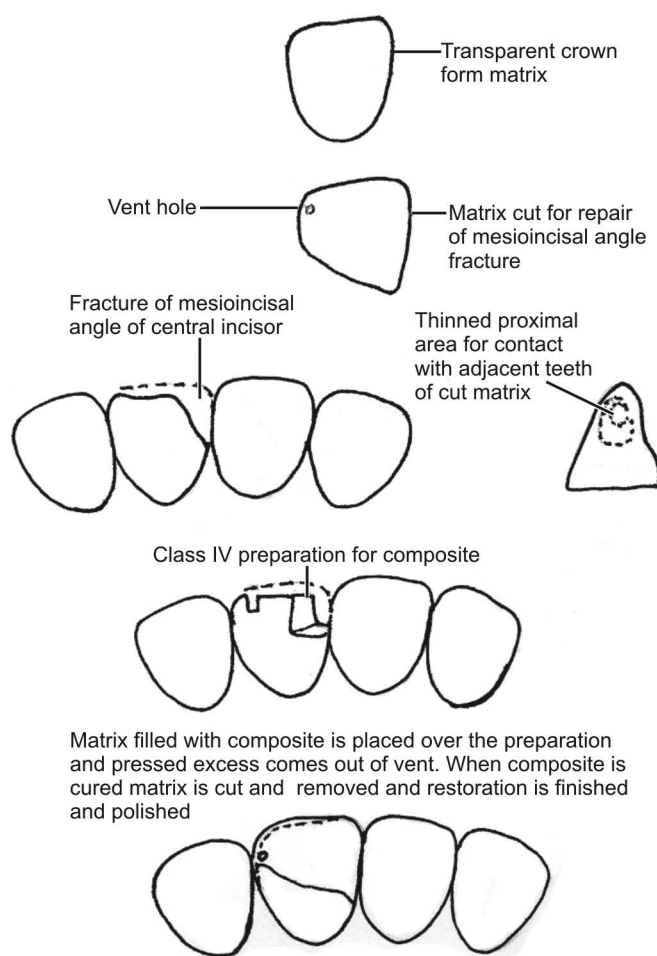
is folded over the incisal edge. The matrix is held with the thumb of the left hand till the initial setting or curing takes place (Fig. 13.12).

## 2. Prefabricated matrices:

- A. *Aluminium foil incisal corner matrix:* These are shaped according to the angles and surfaces of anterior teeth and are prefabricated 'Stock' metallic matrices. They are used for restoring proximo-incisal corners and surfaces of anterior teeth, adapting to specific cases. They cannot be used for light cured resin material.
- B. *Transparent crown form matrices:* These are 'Stock' plastic crowns and can be adapted to tooth anatomy. The entire crown is used for bilateral class IV preparation mesio-inciso-distal (MID). For unilateral class IV the plastic crown is cut incisogingivally to use one half of the crown according to the side of restoration (Fig. 13.13).

## Anatomic Custom Made Matrix

In multiple involvement, where the restoration (s) is (are) part of the disclusion mechanism, full arch study models should be made and mounted in centric occlusion. In

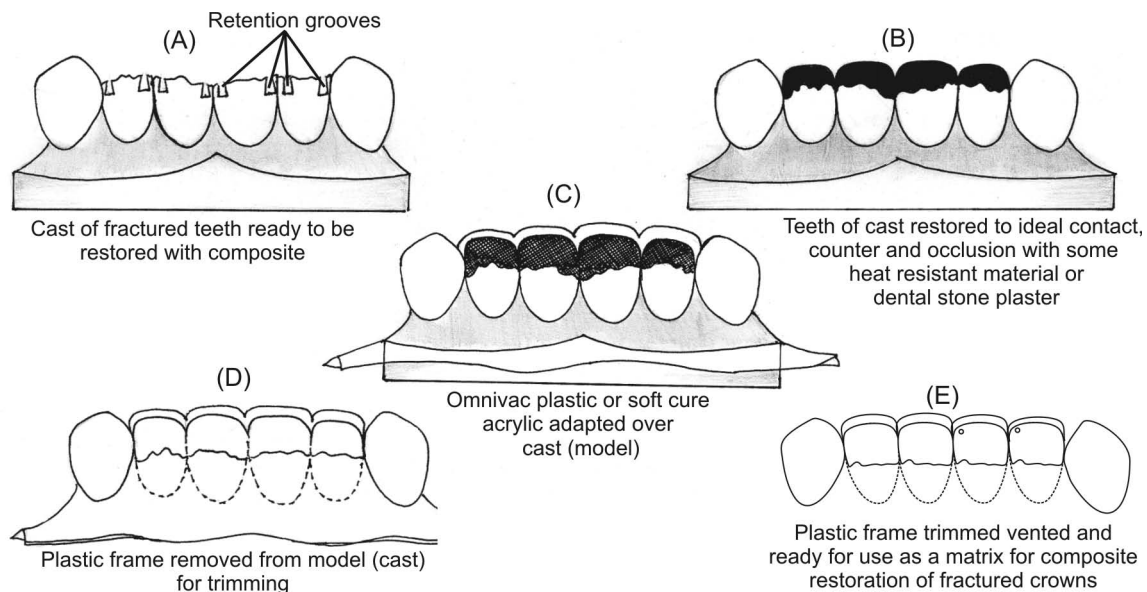


**Fig. 13.13:** Readymade transparent crown form matrix for repair of fracture of mesioincisal angle of central incisor

single tooth involvement before preparing the teeth, study model of affected tooth together with at least one intact adjacent tooth on each side is made.

The defective area (s) is (are) restored on study model to their appropriate configuration by a fairly heat resistant material (plaster, plasticine, acrylic resin, blocking compound, etc).

A plastic template is made for the restored tooth (teeth) on the model using a combination of heat (to thermoplastically soften the template materials) and suction (vacuum) consequently to draw the moldable material onto the study model. The template is trimmed gingivally to fit the teeth and adjacent periodontal structures. It should seat on at least one unprepared tooth on each side. This is the matrix, which should be vented by perforating the corners of its part corresponding to the future restoration. The restorative material is inserted



**Fig. 13.14:** Fabrication of anatomic custom made matrix for individual specific requirement where multiple surfaces or teeth are to be restored

into the preparation, then the matrix is filled with the material and inserted and properly seated over the prepared and partially filled tooth/teeth and are ready for curing (Fig. 13.14).

Matrices for class V, VI and VII cavity preparations for direct tooth-colored restorations.

1. *Prefabricated plastic matrices*—They are used in light cured restorations and are available in different sizes. A handle is present to hold the matrix in place till it sets.
2. *Anatomic matrix for light and non-light cured, direct tooth-colored materials*—Anatomic matrix is fabricated as described for class IV cavities. Study cast of defective tooth/teeth with at least one intact tooth on each side is made. After restoring the defects on the cast, a plastic template is prepared. The template is cut all around, keeping it at least 1 mm beyond the defects. After being trimmed gingivally it is used as a matrix for applying pressure on restorative material while it is being cured.
3. *Aluminium or copper collars for non-light cured tooth colored restorations*—These are pre-shaped according to the gingival third of the buccal and lingual surfaces. They can be adjusted to specific cases to cover 1 to 2 mm of the tooth surface circumferential to the cavity

margins. They are then mounted on the tip of a softened stick of compound, being used as a handle. Fill the cavity with restorative materials and apply the adjusted collar onto the tooth till the initial setting is over.

## WEDGES (SEPARATORS)

For immediate separation of teeth prior to restoration, wedges or separators are used.

Movement of teeth may be required for the following.

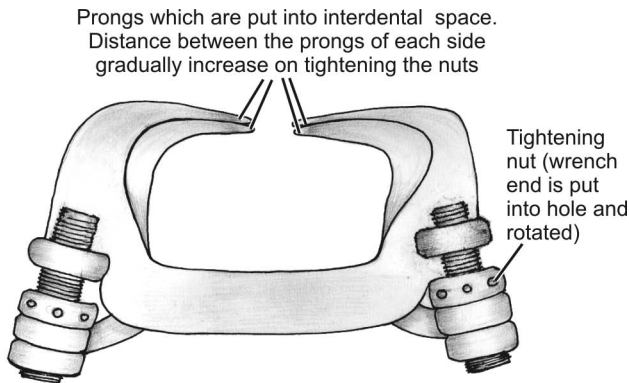
1. To make them restorable by moving them in a desired physiologic position.
  2. By intruding or extruding teeth to make them restorable.
  3. To close space between them to promote a balanced and esthetically pleasing arch form.
  4. To allow space for the thickness of the matrix band.
- Tooth separation may be rapid or slow.

### Rapid or Immediate Separation

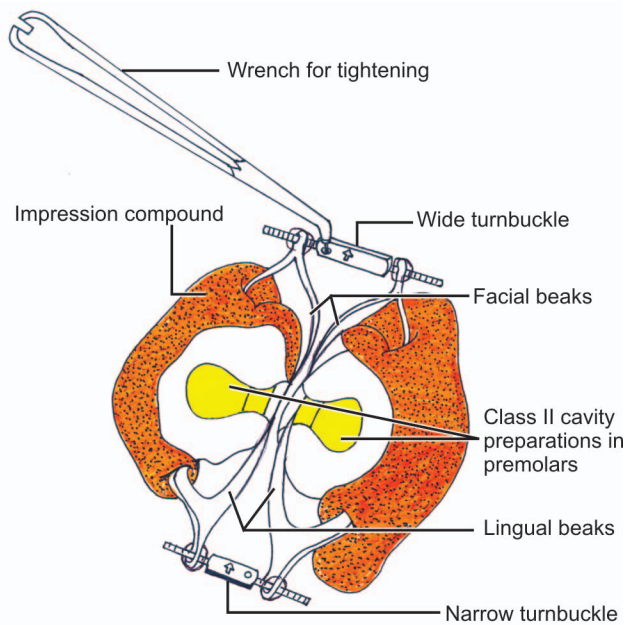
It is a quick and clinically useful method but if excessively used may produce pain due to rupture of the periodontal ligament fibers hence it should be avoided. Separation works on the following two principles.

- Traction Principle
- Wedge Principle





**Fig. 13.15:** Non-interfering true separator (mechanical separator for quick separation)



**Fig. 13.16:** Ferrier double bow separator

Examples of separators working on 'Traction principle' are as follows:

- Non-interfering true separator**—It is used when continuous stabilized separation is required. The separation can be adjusted as per requirement and is shared by adjacent teeth. It does not interfere with occlusion and functions of teeth (Fig. 13.15).
- Ferrier single or double bow separator** (Fig. 13.16)
- Ivory adjustable separator**

- Wood ward separator**
- Perry separator**
- Dentatus nystrom separator**
- Parr's universal separator.**

## FERRIER SEPARATOR

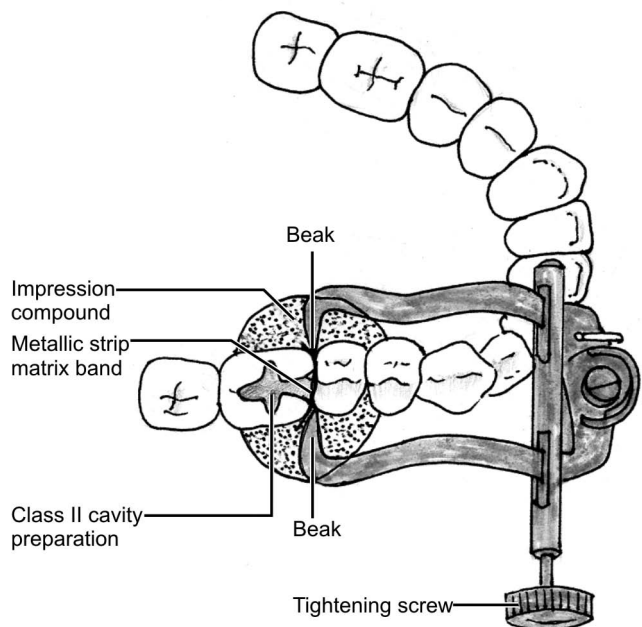
It may be single or double jawed. A wrench is used to tighten it.

Impression compound is used to stabilize it (Fig. 13.16).

These mechanical devices engage the proximal surfaces of teeth and separate them by means of holding arms.

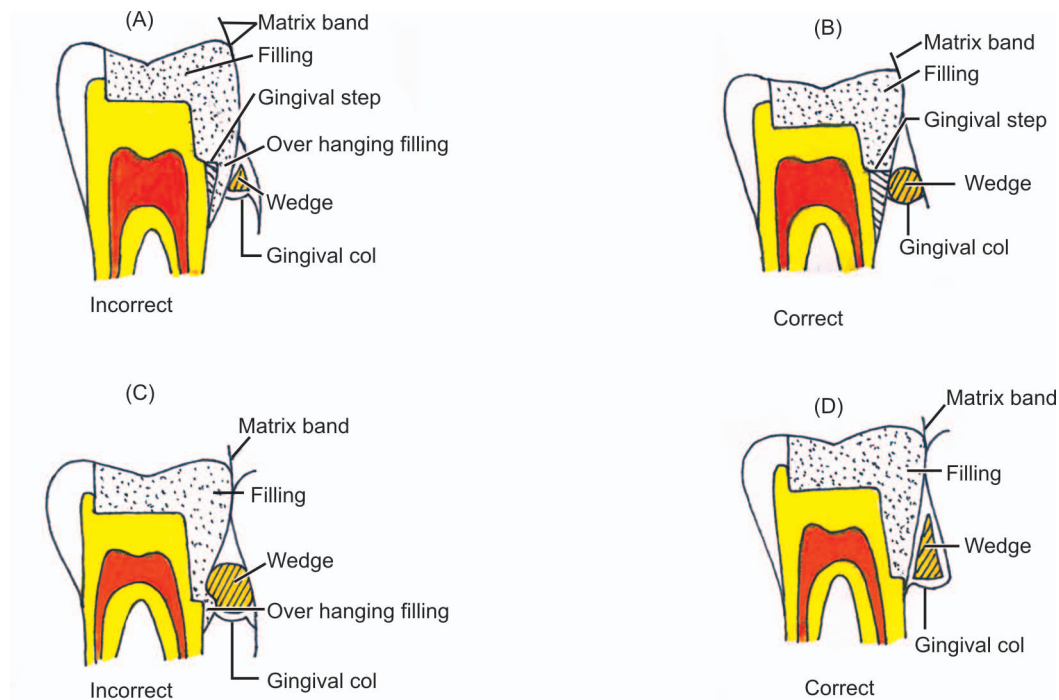
Examples of separators working on 'Wedge principle' are as follows.

- Elliot wedge or separator:** It is a mechanical separator used for examining, contouring or final polishing of a proximal restoration. It is also called as the 'crab-claw' separator. It is less forceful and requires impression compound for stabilization. Its tightening screw can be removed and inserted from the other side if it is to be used on the other side of the arch (Fig. 13.17).



**Fig. 13.17:** Elliott wedge or separator-separating teeth and holding metallic strip matrix band. Impression compound supporting (re-enforcing) matrix band and beaks of separator





**Fig. 13.18:** Various shapes of wedges, their placement and effects of correct and incorrect wedges.

- A. In conservative class II preparation where gingival step is much above the gingival 'col', the triangular wedge is unable to support the matrix band against the gingival step thereby reproducing overhanging margin.
- B. In conservation class II preparation where gingival step is much above the gingival 'col', the round wedge will properly support matrix band against the gingival step (because its wedging action is nearer the gingival step) thereby producing proper margins.
- C. In class II preparations with deep gingival step the thick round wedge, whose major portion is above the gingival step will crimp the matrix band.
- D. In class II preparations with deep gingival step the acute apex triangular wedge (as shown in figure) will reproduce proper margins.

**B. Wedges:** The wedge is used to stabilize matrix band and retainer. If a proximal restoration will involve all of the contact area or extends subgingivally, wedge is inserted in the gingival embrasure after rubber dam application. Wedge may be made of wood, plastic or metal.

Wooden wedges are preferred since they can be trimmed by a scalpel to exactly fit each gingival embrasure, and absorb water to improve interproximal retention. Wooden wedges can be triangular or round. Correct shape and their placement is very important for correct proximal contour of the filling (Fig. 13.18).

Functions of Wedges—Wedges have following functions:

- A. Wedges separate the teeth.
- B. They depress the interproximal soft tissues thus minimizing trauma.

C. Protect the dam and soft tissue from injury.

D. Assure close adaptability and stabilization of matrix band to the tooth.

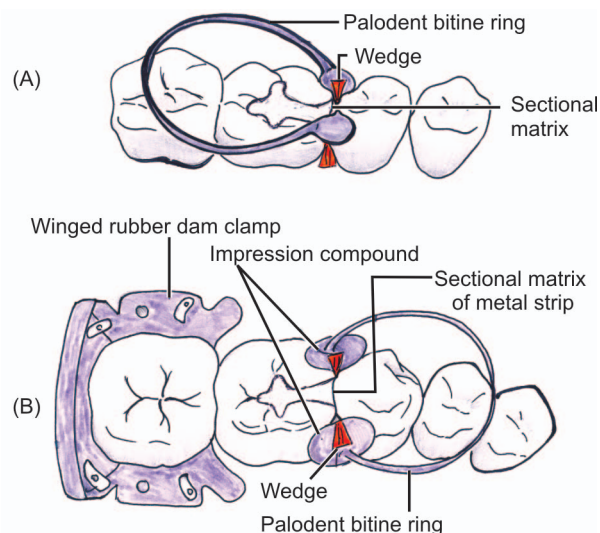
E. Produce separation of the teeth to help compensate for the matrix thickness.

F. Prevent gingival 'overhang' of the restoration.

Sometimes 'Piggy-back' wedging, i.e. a smaller wedge together with a larger wedge may be used in cases of interproximal tissue recession. The decision of inserting the wedge from lingual or buccal side depends on the cavity preparation and space available.

### **Slow Separation**

Severely tilted or drifted teeth may be moved by means of slow separation. Thus, the repositioning occurs physiologically without any chance of injuring periodontal ligament fibers.



**Fig. 13.19:** Palodont Bi Tine spring ring wedge providing separation and holding sectional matrix in place on the mesial side of the first molar [A] Continuous ring end is towards distal side (B) Impression compound adapted over ring tines and wedge is used for better adaptation of the matrix. Continuous ring end is towards mesial side. Winged rubber dam clamp is seen on the second molar with arm on the distal side

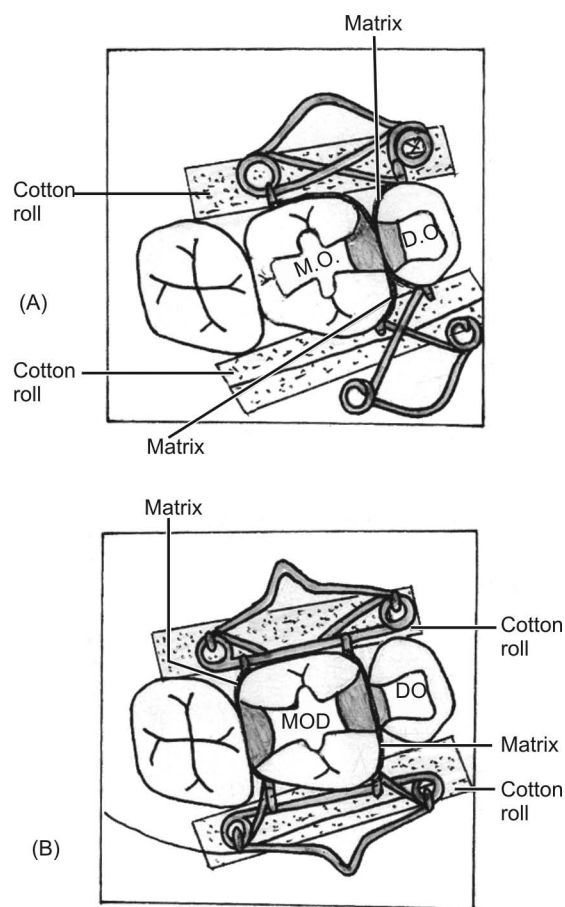
Materials used for slow separation by putting slow continuous separating pressure include the following:

- Separating wires tightened around teeth.
- Gutta percha softened and packed between the teeth to be separated.
- Base plate softened and packed between the teeth to be separated.
- Orthodontic appliances.

### PALODENT BITINE SPRINGY RING WEDGE

**Wedge and matrix for class II cavity for composite:** Due to increasing popularity of class II composite restorations there has arisen need for a wedge which separates the teeth and also holds in position the sectional matrix. Palodont Bitine springy ring wedge is the answer to the problem.

This is specially indicated for composite as composite is an absolutely passive material and does not compact itself into the cavity like amalgam. The 'BITINE' springy ring wedge along with matrix is shaped to provide the proximal form of a posterior tooth including all embrasures. About 3 mm globule of impression compound is applied to each of its tine tips. The ring is



**Fig. 13.20:** Retainerless Walser filling matrix (A) for MO and/or DO cavity (B) for MOD cavity

grasped with rubber dam forcep and impression compound is quickly warmed over alcohol flame to soften the outer layer of the impression compound. It is then carried into the oral cavity and beaks are placed into the embrasures of the cavity side and ring is allowed to shrink. Due to spring action ring firmly and rigidly seals the sectional matrix band around the missing wall of the cavity and also acts as a separator between the teeth.

After seating the wedge a small (4 to 6 mm long) sectional matrix band is inserted then gingival wedge is inserted under the contact area. The matrix band is properly contoured with a ball burnisher so as to perfectly adapt it to the tooth walls with the help of impression composition and the ring matrix (Fig. 13.19).

After checking the fit of the matrix band the filling material is condensed in the cavity and carving is done. Then the ring is spread apart and removed. The wedge

## 150 *Textbook of Operative Dentistry*

and matrix band and excess material are laterally removed and carving is done on proximal side before the teeth return to their original positions leaving good proximal contoured restoration and tight contact points. Now restoration is finished and polished as usual.

### **RETAINERLESS WALSER FILLING MATRIX**

It is designed, for fitting and removal within a few seconds. It is durable and sterilizable. It fits tightly and safely while automatically adapting to conical tooth shapes. It does not require any screws or spanners. Patients can close their mouths and bite when the matrix is in place, hence occlusal carving can be done without removing it (Fig. 13.20). Along with matrix it is also suitable for use as a cotton wool roll holder. The matrix is available in 27 sizes, with blade heights ranging from 5 to 8 mm and thickness of 0.05 mm. The matrix comes in sets of 10, 18, and 25 matrices with forceps and sterilizing tray.

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The goal of infection control is to prevent the spread of infection from one patient to another or a treating health care worker (HCW) or *vice versa*. Prevention of cross-infection is the most important aspect of infection control. The measures to prevent cross-infection should be practical, economical and effective. Dental surgeon, hygienist, assistants and laboratory technician are frequently exposed to infectious diseases.

## PROCEDURES

Many sources of potential infections exist in the dental clinic. Hand, blood, saliva, instruments and equipment all contribute to transmission of microorganisms from one person to another during treatment procedures. The following procedures should be followed routinely to protect dental personnel and to prevent transmission of infectious diseases from one person to another.

1. Face masks should be worn to protect oral and nasal mucosa from minute droplets of blood and saliva.
2. Gloves should be worn for examining and treating patients. They should be changed after contact with each patient.
3. Rubber dam, high-speed evacuation and proper patient positioning should be utilized to minimize generation of droplets and splatter.
4. Handpieces should be sterilized after use with each patient since blood, saliva or gingival fluid may be aspirated with handpieces. Handpieces that cannot be sterilized should be flushed and the outside wiped with a chemical germicide.
5. Blood, saliva and gingival fluid must be thoroughly and carefully cleaned from material that has been used in the mouth (e.g. impression material, bite registration), especially before polishing and grinding intraoral devices. Contaminated materials, impressions and intraoral devices should be cleaned and disinfected before being handled in a dental laboratory and before they are placed in the patient's mouth.
6. Dental equipment and surfaces that are difficult to disinfect (light handles or X-ray units) should be wrapped with impervious backed paper, aluminium foil or clear transparent polythene wrap. The coverings should be removed and discarded and fresh clean wrapping done, after use with each patient.
7. Syringes or needles once used to inoculate local anesthetic into a patient should never be used again to re-enter a multidose vial of local anesthetic. The use of multidose vials must be avoided.
8. Eyes should be protected with some type of covering like absolutely transparent protective shield or eye glasses. If the eyesight is normal, powerless glasses may be used.
9. Methods of sterilization known to kill all microorganisms, including steam autoclave, dry heat oven, chemical vapor sterilizers and chemical sterilants, etc. should be used.
10. Instruments and surfaces in the operatory should be cleaned. This includes scrubbing with detergent solution and wiping down surfaces with iodine or chlorine solution.
11. Contaminated disposable materials should be handled carefully and discarded in plastic bags to minimize human contact.
12. To handle used instruments wear protective puncture resistant gloves.
13. Before cleaning keep all instruments wet in an antibacterial solution.
14. For cleaning instrument use an ultrasonic vibrator
15. Use and maintain best quality sterilizing equipment.

*Cold sterilization:* This includes sterilization at room temperature, usually with an aqueous solution of a chemical or gas.

*Cross infection:* The transmission of infectious diseases from one person to another.



## 152 Textbook of Operative Dentistry

**Disinfection:** It is the destruction of pathogenic microorganisms by directly applied chemical or other physical methods.

**Disinfectants:** The chemicals which are capable of killing pathogenic organisms, when applied to inanimate objects

**Nosocomial:** This includes clinic or hospital-acquired infections.

**Sepsis:** The presence of pathogenic microorganisms in the blood or other tissues.

**Antiseptics:** This includes agents that prevent the growth or action of microorganisms on living tissue.

**Asepsis:** The opposite of sepsis, i.e. the absence of pathogens in the blood or other tissues.

**Sterilization:** The destruction of all microbial life forms is called sterilization. This includes the use of physical or chemical methods to eliminate all viable microorganisms, for example bacteria, viruses and spores.

Infection control provides a safe environment for all concerned, patients, dental surgeon and auxiliaries. The major route of transmission of respiratory and oral microorganisms is by the hand. It is a must that nails be kept as short as possible and all finger rings removed prior to touching the patient. Hands should be cleaned thoroughly with a hand-cleaning soap and brush. Each hand scrubbing and washing should take at least 15 seconds. Hand cleaners containing a number of antimicrobial agents (chlorhexidine, iodoform, alcohol, etc.) are available in several brands. There are various brands of non-irritating lotions containing antimicrobial agent, especially useful for operators with sensitive skin. Gloves must be worn routinely during oral examination and double gloves during all operative procedures. Repeated use of same gloves is not recommended since such use is likely to produce microspore defects in the gloves and cause it to leak. Gloves are available in small (no.s 5 and 6) medium (no.s 7 and 8) and large (no.s 9 and 10) sizes. Thicker and heavier (slightly larger size) gloves (usually used by electricians) should be worn when disinfecting the instruments. Polythene (over gloves) are naturally oversized and are convenient to slip over a gloved hand especially when talking on the telephone or writing prescription. Over gloves are easily worn and removed during the operating procedures (Tables 14.1 and 14.2).

Protective eye wear (eye glasses) and surgical masks should be worn particularly when rinsing, irrigating and polishing the cavity, oral prophylaxis and during laboratory work. They protect against splashing or splattering of blood or other body fluid. Double face masks must be worn continuously whenever the operator or patient has a respiratory infection. There are significant differences in the brands and types of face masks as per fitting and comfort. A suitable brand should be chosen that feels comfortable on the face. It is wise to wash eyeglasses or eye wear frequently during the day.

The use of high velocity evacuation greatly decreases the amount of aerosols. Splatter and contamination can be further decreased by having patients thoroughly remove their dental plaque with a brush, dental floss and use of broad spectrum mouthwash such as chlorhexidine gluconate (0.12 %) or povidone iodine (0.5 to 1 %). Hair should be kept away from the treatment field. Covering protects the hair of operator and patient from splatter and aerosols. Pathogenic bacteria and some viruses, especially hepatitis B, can survive for days on clothing hence after every use clothing must be washed and autoclaved.

### OPERATORY ASEPSIS

During the course of treatment many objects, instruments, surfaces and equipment become contaminated either directly by hands or indirectly by aerosols and splatter. Hence, it should be decided which items can be covered and sterilized and which must be disinfected. Horizontal surfaces are subject to considerably more contamination than vertical surfaces. Because of this reason, cleaning and disinfecting the horizontal flat surfaces should be done after every patient and of vertical surfaces daily.

### Procedure for Preparation of the Dental Chair, Dental Unit and Instruments

- A. Cleaning of unit and instrument after attending the patient
  1. After treatment remove chair seat, back and head rest cover with gloves on.
  2. Discard cotton rolls and other disposable material into the cover. Discard cover into covered dustbin.
  3. Aseptically remove and discard disposable gloves and disposable tumbler.



**Table 14.1:** Effectiveness of sterilization and disinfection of dental instruments

| Instrument/<br>materials                             | By various methods                  |                                |                                |                                               |                                                                                           |
|------------------------------------------------------|-------------------------------------|--------------------------------|--------------------------------|-----------------------------------------------|-------------------------------------------------------------------------------------------|
|                                                      | By steam<br>autoclave               | By dry heat<br>oven            | By chemical<br>vapor           | By chemical<br>disinfection/<br>sterilization | By other<br>methods                                                                       |
| 1. Burs                                              |                                     |                                |                                |                                               |                                                                                           |
| i. Carbon steel                                      | Effective method but risk of damage | Effective and preferred method | Effective and preferred method | Effective method but risk of damage           | —                                                                                         |
| ii. Steel                                            | Effective and accepted method       | Effective and preferred method | Effective and preferred method | Effective method, but risk of damage          | —                                                                                         |
| iii. Tungsten Carbide                                | Effective and accepted method       | Effective and preferred method | Effective and accepted method  | Effective and accepted method                 | —                                                                                         |
| 2. Endodontic instruments (broaches, files, reamers) | May be used                         | May be used                    |                                |                                               | Preferred method is Hot salt/glass bead sterilizer for 10 to 15 seconds at 218°C (425° F) |
| 3. Stainless steel handles                           | Effective and accepted method       | Effective and preferred method | Effective and preferred method | Effective and accepted method                 | —                                                                                         |
| 4. Mirrors                                           | Effective method but risk of damage | Effective and preferred method | Effective and preferred method | Effective and accepted method                 | —                                                                                         |
| 5. Glass slab                                        | Effective and preferred method      | Effective and preferred method | Effective and preferred method | Effective and accepted method                 | —                                                                                         |

**Table 14.2:** Effectiveness of disinfecting agents for impressions and appliances

| Materials                            | Disinfecting<br>Glutaraldehyde | agents<br>Iodophor | 0.5% NaOCl | Phenols |
|--------------------------------------|--------------------------------|--------------------|------------|---------|
| Impressions compound                 | No                             | Yes                | Yes        | ?       |
| Alginate                             | No                             | Yes                | Yes        | No      |
| Polysulphide                         | Yes                            | Yes                | Yes        | Yes     |
| Silicons                             | Yes                            | Yes                | Yes        | Yes     |
| Polyether                            | No                             | Yes+               | Yes+       | Yes+    |
| Hydrocolloid                         | No                             | Yes                | Yes        | ?       |
| Appliances                           |                                |                    |            |         |
| Removable orthodontic                | No                             | Yes                | No         | No      |
| Complete denture (acrylic/porcelain) | No                             | Yes                | Yes        | No      |
| Removable partial (Metal acrylic)    | No                             | Yes                | No         | No      |
| Fixed prosthesis (Metal/porcelain)   | Yes                            | Yes                | No         | ?       |

+ Polyethers are sensitive to immersion. Spraying with disinfectant, then wrapping in disinfectant-soaked towel is least likely to damage the impression.

4. Wash hands with soap and water and dry.
5. Put on sterile latex utility gloves. On seat of dental chair, over three layers of paper napkin place air/water syringe and suction tips.
6. Discard disposable air/water syringe and suction tips into the dustbin.
7. Discard all disposable sharps into sharps container.

## 154 Textbook of Operative Dentistry

8. Remove hand pieces and sterilize them.
  9. Place all instruments into disinfectant solution.
  10. Remove instruments from disinfectant solution and then place into the ultrasonic vibrator.
  11. Spray disinfectant on used bottles, containers, tubes and unused burs. Wipe with sterile paper napkin. Spray disinfectant again before using.
  12. Remove and discard plastic drapes from the dental chair and unit, light, tables, trolleys, etc.
  13. Uncovered items, controls and switches are cleaned with paper napkin wetted with disinfectant and squeezed. Discard paper napkin in the covered dustbin.
  14. Once again clean them with a paper napkin wetted with disinfectant and squeezed.
  15. Flush water in cuspidor (spittoon). Spray cuspidor (spittoon) with disinfectant solution. Wipe with paper towels or napkins and discard them.
  16. Wipe operatory floor with disinfectant in disposable towels. Discard these towels. Respray all areas with disinfectant and leave damp.
  17. Wash utility gloves (still on hands) with strong antiseptic hand scrub or disinfectant. Rinse thoroughly. Dry with sterile paper napkins. Discard napkins.
  18. Remove utility gloves, disinfect and rehang them
  19. Wash hands.
- B. Preparation of unit for next patient
1. Use as much sterile disposables as possible. Put on sterile gloves.
  2. Cover chair arms, head rest, back rest and chair seat with disposable sterile polythene sheets.
  3. Install sterilized air/water and suction tips and handpieces.
  4. Set out materials and instruments.
  5. Replace disposable tumbler.
  6. Seat the patient and put on sterile mask, eyewear and gloves.
  7. Cover chest of the patient with clean and sterile napkin.

### DISINFECTION OF DENTAL CAST

All dental impression should be washed thoroughly in running water and disinfected before pouring the casts. If dental impressions are not disinfected then casts

should be disinfected to prevent possible cross-infection to dental office and laboratory personnel by microorganisms and viruses. Disinfecting agents should not adversely affect surface quality and accuracy of the resulting casts. For preparing casts from disinfected impressions, disinfected stones and plasters having disinfectant should be used. Impressions of patients with hepatitis B virus and human immunodeficiency virus (HIV) should be sterilized properly by the over night gas sterilization before pouring the casts or casts should be such sterilized before working on them.

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Any operative procedure cannot be performed properly without pain control. Pain enhances the chances of apprehension, nervousness, syncope and shock during treatment. A patient who is not in a calm state may interfere with treatment and is prone to injury during treatment. All these lead to decreased work output and poor quality of work.

Usually pain control in a dental clinic can be obtained by the following methods.

1. The use of high speed and ultrahigh speed rotary instruments with sharp burs and coolants.
2. Local anesthesia
3. Analgesia
4. Hypnosis
5. General anesthesia

### **THE USE OF HIGH SPEED AND ULTRAHIGH SPEED ROTARY INSTRUMENTS WITH SHARP BURS AND COOLANTS**

When new and sharp burs of appropriate sizes are used with high speed and ultrahigh speed with coolants the pain is almost eliminated during all operative procedures. Even lengthy and complicated procedures are performed very quickly without any discomfort to the patient.

### **LOCAL ANESTHESIA**

Commonly local anesthesia is given parenterally. A very small amount is adequate for the various operative procedures. Before injection topical anesthetic solution is applied on the site where the injection is to be given to eliminate pain of injection. The solution should be at body temperature and sensitivity test must be done before injecting the required dose.

### **ANALGESIA**

Inhalation sedation may be used for the patient who has a low threshold of pain and are very apprehensive. In these

patients, nitrous oxide and oxygen increase threshold of pain. Inhalation sedation does not mean general anesthesia rather it is sometimes given along with local anesthetic injections to elevate threshold of pain. With this patient is conscious of surrounding activities.

### **HYPNOSIS**

Hypnosis is also used to reduce or alleviate apprehension and pain. It is done through suggestion of relaxation. Dental surgeon should have knowledge about the patient having conditions associated with psychological, emotional and mental factors. Patient undergoing hypnosis feels relaxed and less fatigued at the end of dental treatment. During treatment, dental surgeon and patient remain in a more relaxed environment.

Classification of patient given by American Society of Anesthesiology according to the physical status is as follows.

- A. Normal healthy individual.
- B. Patient with mild to moderate systemic disease.
- C. Patient with severe systemic disease that limits activity but is not incapacitating.
- D. Patient with severe systemic disease that limits activity and is a constant threat to life.
- E. Moribund (dying) patient not expected to survive twenty four hours with or without operation.

Before administering local anesthesia, a medical history proforma having history of following systemic problems must be completed and signed by the patient or his close relative.

### **Cardiovascular System**

Patient's heart rate, blood pressure (BP), and pulse rate should be evaluated. A patient having heart disease like valvular defect should be operated under antibiotic coverage.

Large amount of anesthetic drugs may cause decreased blood pressure which leads to unconsciousness due to reduced oxygen supply to the brain. Generally, local anesthetic preparations contain 1:80,000 to 200,000 concentration of adrenaline and

2 percent local anesthetic salt, which have good safety margin. The increased concentration of adrenaline may cause increase in blood pressure, rise in heart rate and arrhythmia also. In cardiac patients local anesthetic solution without adrenaline should be used.

## CENTRAL NERVOUS SYSTEM

Side effects of the local anesthesia are more common in central nervous system. Therapeutic dose generally may cause depression. Very high dose may cause tonic-clonic seizure, decreased blood pressure and respiratory arrest leading to death.

**Allergy :** Most dangerous complication is allergy, because it is life-threatening in most of the cases. Hence, proper history about allergy is mandatory before administering local anesthesia.

**Pregnancy :** During first trimester of pregnancy, surgical dental treatment should not be advised. It is better to use minimum amount of local anesthetic drug specially during pregnancy.

**Hepatic dysfunction:** In hepatic dysfunction, the biotransformation cannot take place properly. It causes high level of local anesthetic in the blood. Therefore, low doses of local anesthetic should be administered.

**Renal dysfunction:** In patients with kidney diseases, local anesthetics do not cause any extra problem to the patient.

**Thyroid diseases:** Careful finding for uncontrolled hyperthyroidism is required because such patients exhibit increased response to the vasoconstrictor (adrenaline) present with local anesthetics. Therefore solutions without adrenaline should be used.

**Age:** In very young and extremely old persons, less than the normal therapeutic dose should be given.

## Advantages of Local Anesthesia

Following are the main advantages of local anesthesia during dental procedure.

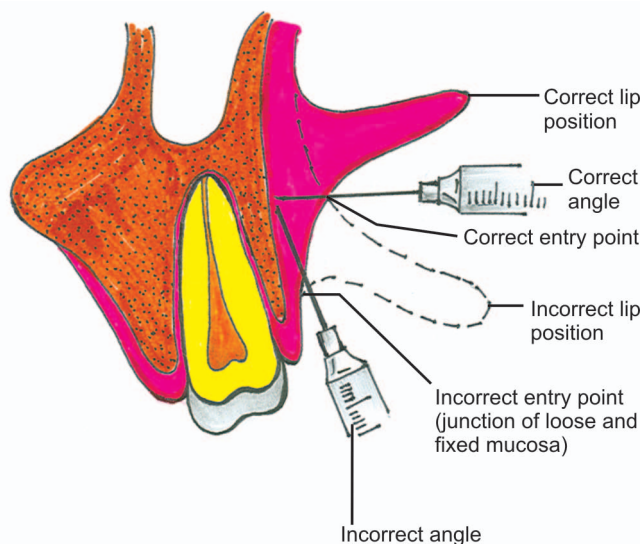
1. **Better patient co-operation:** If the region or tooth is fully anesthetized patient does not feel pain. It removes fear and apprehension. Patient appears relaxed and gives better cooperation and dental procedure can be done in a calm environment.

2. **Control of saliva:** Increased flow of saliva during dental procedure is the consequence of “touch” sensation to various parts of the oral cavity during treatment. Under local anesthesia, there is reduction of sensation which results in decreased salivary flow.
3. **Control of bleeding:** In the local anesthesia, a vasoconstrictor, usually epinephrine or adrenaline is added mainly for increasing the period of anesthesia by decreasing flow of blood at the site of injection. This temporary reduction in blood flow helps in controlling bleeding during any dental procedure.
4. **Operative efficiency:** By the use of local anesthesia, pain disappears, which is associated with reduced blood flow and apprehension. Under local anesthesia, the patient is most co-operative. Therefore, the confidence and work efficiency is increased.

## Steps in Administration of Local Anesthesia

1. Patient should be in supine position. This is preferred because it favors good blood supply and pressure to brain.
2. **Syringe aspiration:** Before injecting the solution into the body, first a little aspiration in the syringe is done to avoid chances of injecting solution in the blood vessels and consequently preventing toxic effect of local anesthesia.
3. The local anesthetic solution should not be injected into the inflamed and infected tissues to prevent possible spread of infection. In inflamed areas, the local anesthetic solution does not work properly due to acidic medium of inflamed tissues.
4. In every patient, disposable needle and syringe should be used. The needle should be of proper gauge and length. Needle should remain covered with cap till its use.
5. Before loading syringe the temperature of the solution should be brought to body temperature to make injecting a painless procedure.
6. Before loading the solution in the syringe, it should be confirmed that anesthetic solution is fresh and not expired.





**Fig. 15.1:** Correct angle of needle for injecting local anesthesia on the buccal side of upper premolar

7. Before injecting the local anesthesia, the site of injection should be cleaned free of debris and saliva by a sterile cotton pellet.
8. Topical surface anesthetic solution or jelly may be applied before injecting the needle for painless penetration of needle.
9. Needle should be inserted at the junction of alveolar mucosa and vestibular mucosa and the angle of needle should not be parallel to the long axis of the tooth, but at an angle as recommended. Injection parallel to long axis causes more pain (Fig. 15.1).
10. Anesthetic solution is injected slowly not more than 1 ml per minute and in small increments to provide enough time for tissue diffusion of the solution. Needle should be continuously inserted inside till the periosteum or bone is felt by way

of slight increase in resistance of the needle movement. The needle is slightly withdrawn and here the remaining solution is injected.

11. Two minutes after injection the effect of anesthesia is checked before starting operative procedure.
12. Patient should be carefully watched during and after local anesthesia for about half an hour for delayed reactions, if any.
13. After use, the needle and syringe should be discarded in a container. The container should be leak-proof and hard-walled.

Therefore for the control of discomfort and pain the use of sharp burs, coolants, hypnosis, analgesia and local anesthesia must be used to make operative procedures pleasant and acceptable to the patient.

*General anesthesia:* It is only required when all the above methods fail or the mouth opening is poor

For details 'Textbook of Dental Anesthesia with MCQs' by the authors may be referred.

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During cavity preparation and after removal of caries from a tooth, the major objective of the operator is to maintain the pulp in good health. If pulp is having reversible hyperemia its health should be restored before permanent restoration is done. The health of the pulp is also affected by the restorative materials, an improper selection of restorative materials may even cause pulpal necrosis.

## DENTAL PULP

Dental pulp is a vascular, innervated connective tissue which occupies the pulp chamber of the tooth. Pulp, because of its connection to systemic circulation is responsible for the vitality of the tooth.

The main functions of the dental pulp are as follows:

- a. *Formative*: It helps in the formation of the dentin that surrounds the pulp.
- b. *Nutrition*: Through the odontoblasts pulp supplies nutrition to the dentin.
- c. *Sensory response*: The dental pulp provides sensory response to the external stimuli caused due to temperature changes, pressure and operating procedures.
- d. *Defensive*: Due to irritation, cellular defensive action in the pulp takes place. By mineralization of the affected tubules and formation of the reparative dentin, the pulp tries to wall off irritation.

## FACTORS AFFECTING THE HEALTH OF THE PULP

Any stimulus that affects the health of the pulp will reach the pulp through the dentinal tubules, whether it is from dental caries, masticatory attrition or due to operative procedures.

### Dental Caries

When the caries reaches the deeper layers of dentin, pulpal stimulation takes place, in response to which formation of reparative dentin takes place. If before the

pulp is irreversibly affected, proper restoration is done, the pulp with reversible hyperemia will return to normal health. Any carious lesion, if left untreated, will progress and expose the pulp tissue and will cause inflammation, resulting in severe pain and gradually death of pulp.

### Instrumentation

Tooth preparation with hand and rotary instruments for removal of caries and cavity preparation may cause changes, not only in tooth anatomy but also in the pulp. During tooth reduction heat is produced, which may cause pulpal inflammation, therefore water-cooled operative techniques are mandatory with which pulpal response to heat is almost eliminated.

The intensity of pulpal response will be less at high speed cutting with proper coolant, than at the low speed without coolant because low force of application is required at high speed. When high speeds are used without water coolant, due to generation of high temperature, adverse pulpal effects result.

### Depth of the Cavity

The deeper the cavity is made, due to decreased remaining dentin thickness, the greater will be the effect of stimuli upon the pulpal tissue. Total number of dentinal tubules cut during cavity preparation influence the pulpal reaction. As the number of the cut dentinal tubules and their proximity to pulp increase the severity of changes in the pulp also increases. In full crown preparation, more surface area is involved, so there will be more pulpal response than that in the simple cavity preparation with equal proximity to the pulp. Greater pulpal response is seen in previously uncut dentinal tubules, while in dentinal tubules lined with reparative dentin, mild pulpal response is there because reparative dentin acts as an insulator.

### Use of Compressed Air

Drying of the prepared cavity by highly compressed air for a prolonged period of time causes desiccation of

## 160 Textbook of Operative Dentistry

the exposed dentin, which can result in damage to the pulp due to the disturbance to the odontoblasts. When the superficial odontoblasts are dried they suck dentinal fluid from the deeper layers, disturbing the water balance of the pulp, resulting in pulpal inflammation.

Precautions for prevention of postrestorative discomfort

1. During cavity preparation an efficient cooling system should be used.
2. Use proper liner or base to seal the openings of exposed dentinal tubules.
3. For drying of the cavity do not use very hot air or compressed air for longer period or over-dry the cavity.
4. As far as possible avoid preparing very deep cavity which may result in pulpal irritation.
5. For sterilization of cavity (if it is to be done), use only very mild agents which may not irritate the pulp. In place of sterilization only clearing with slow jet of water at body temperature and drying of the cavity with dry cotton is recommended.
6. Polishing of the restoration should be done in such a manner that excessive heat is not produced.
7. On periodic recall check-up in case of any discomfort, pulpal status should be evaluated.

### Smear Layer

During cavity preparation by rotary instruments a uniform amorphous structural, relatively smooth microcrystalline debris layer, known as 'smear layer', is formed over the remaining enamel and dentin. It occludes the dentinal tubules. It is composed of denatured collagen, hydroxyapatite and dentin cutting debris and is only few micrometers thick. This layer cannot be seen with the naked eye. This layer reduces the permeability of the dentin and has the potential to protect the dentin from hydrostatic forces produced during mastication. Therefore, it is not desirable to remove this layer except where enamel and dentin etching is to be done. Smear layer also prevents the bacteria from entering into the dentinal tubules but does not prevent the penetration of their by-products, which may result in pulpal inflammation. With increase in post-operative time, smear layer dissolves in organic acids present in the oral fluids. This may lead to increased dentin permeability and pulpal inflammation (Fig. 16.1).

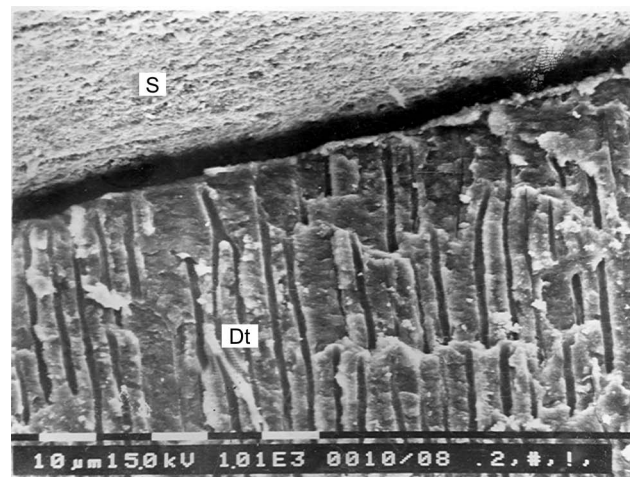
However, another school of thought is in favor of removing the smear layer. They are of the view that (a) microorganisms present in the smear layer may irritate the pulp and periapical tissues and (b) due to smear layer, restorative materials do not adhere to the dentinal walls. Therefore, the entire smear layer must be removed before restoration and root canal obturation (Fig. 16.2).

### PULP PROTECTION IN SHALLOW AND MODERATE CARIOUS LESIONS

A moderate carious lesion is one in which the caries penetrates the enamel and may involve one half of the dentin, but not to the extent of endangering the pulp. After cavity preparation, the liner is applied to cover the axial and/or pulpal wall. Then, base material, which is selected from zinc phosphate, zinc oxide eugenol, glass ionomer or polycarboxylate, is placed over the liner. After the base material hardens, permanent restoration is done (Fig. 16.3).

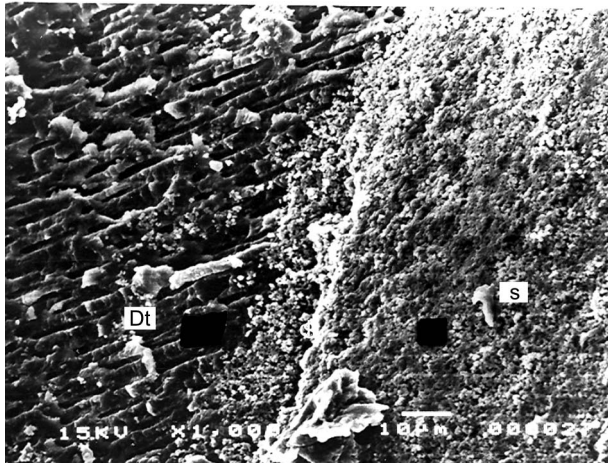
### PULP PROTECTION IN DEEP CARIOUS LESIONS

In deep cavity, the caries can reach upto the pulp, so treatment of deep carious lesion requires precaution



**Fig. 16.1:** Thick black line in between zinc oxide eugenol cement sealer (S) and dentinal tubules (Dt) is 'smear layer' which did not allow entry of sealer into the dentinal tubules. Dentinal tubules are empty due to the presence of the smear layer (SEM magnification 1.01 E3 = approx. × 1000)

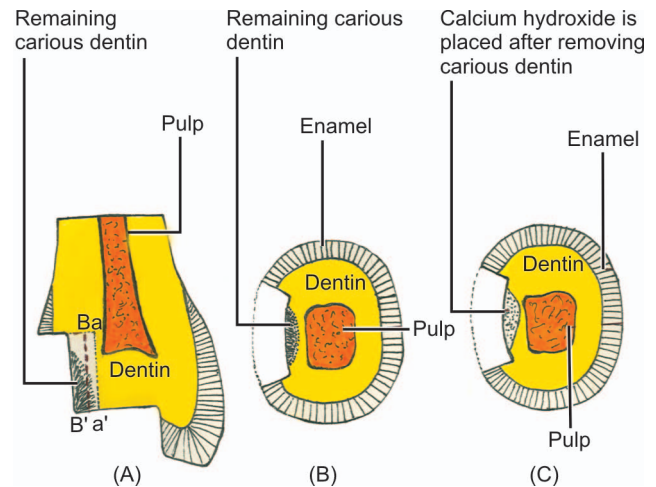




**Fig. 16.2:** Due to absence of smear layer between zinc oxide eugenol sealer and dentinal tubules there is penetration of zinc oxide eugenol sealer into the dentinal tubules (SEM magnification x 1000). S = sealer, Dt = dentinal tubules

because of postoperative pulpal response. After proper diagnosis, the following methods for pulpal protection are employed.

1. If hard dentin is present and there is no threat to the health of the pulp after removal of caries, give protective cement base and complete the permanent restoration as though it was a moderate lesion.
2. *Indirect pulp capping:* In this procedure, all the carious tissue is removed except the soft undiscolored carious dentin which is adjacent to the pulp. If this carious dentin part is also removed, exposure of the pulp tissue will take place. Then the cavity is cleaned, dried and covered by calcium hydroxide and thick mix of reinforced zinc oxide eugenol cement or glass ionomer cement. After 2 to 3 months, the cement is removed and the cavity is inspected. If due to remineralization and/or formation of secondary dentin the soft dentin has become hard, then remove any residual soft debris and then finally give protective cement base and place the permanent restorative material. The success of indirect pulp capping depends on the age of the patient, size of the exposure, restorative procedure and evidence of pulp vitality. In young



**Fig. 16.3:** Management of extensive carious lesion (A) Mesiodistal section, remaining carious dentin on axial wall does not call for as much cutting of axial wall towards pulp as shown by dotted line (a a') After radiographic evaluation cutting of axial wall upto ideal axial wall position, dashed line (B B') can safely be done. (B) Horizontal section, only remaining carious dentin of ideal axial wall position is removed with round bur. (C) A calcium hydroxide liner is placed in excavated areas which are near pulp or showing actual exposure of pulp after removal of carious dentin

patients, the potential for success is more due to large volume of pulp tissue and abundant vascularity.

3. *Direct pulp capping:* The purpose of direct pulp capping is to preserve the vitality of the pulp by placing the medicament over the exposure site, so as to provide an environment for the healing of the pulp. For pulp capping, complete excavation of the carious dentin is done during which pulpal exposure may take place. When vital and healthy pulp is exposed, fresh bleeding of bright red blood will take place. After the bleeding at the exposure site is checked, clean the area with distilled water or saline solution and then dry the area.

Over the exposure site, calcium hydroxide is placed as the medicament which is sealed in place by resin bonded zinc oxide eugenol cement or glass ionomer cement. After 2 to 3 months, the cement is very gently removed to inspect the exposure site. If secondary dentin formation takes place over the exposed site, the

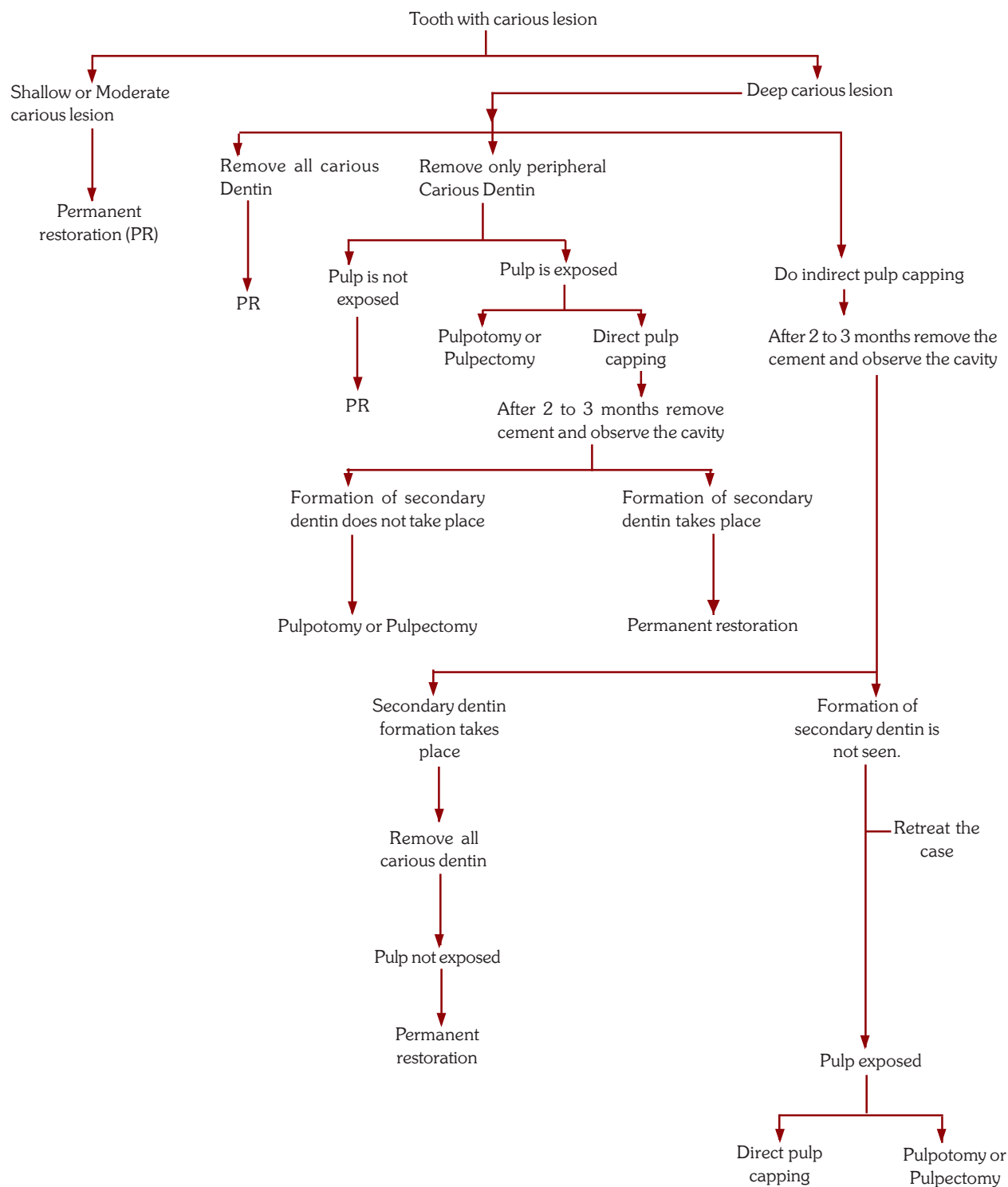


Fig. 16.4: Management of tooth with carious lesion (PR = Permanent Restoration)



tooth is restored permanently with protective cement base and restorative material. If favorable prognosis is not there, pulpotomy or pulpectomy is done (Fig. 16.4).

The factors on which the success of direct pulp capping depends are as follows:

1. *Age of the patient:* Due to vascularity of the pulp, young patients have greater potential for success than older ones.
2. *Type of exposure:* Mechanically done pulpal exposure has greater potential for success than exposure caused by caries, due to the possibility of less pulpal inflammation and deleterious effect of bacterial toxins on the pulp.
3. *Size of the exposure:* In large exposures, it is difficult to control the hemorrhage and tissue seepage. Placement of a continuous layer of material in case of large exposure site is difficult. Small pinpoint exposures are easy to manage and have a greater potential for success.
4. *Quality of blood flow:* If very little blood flow takes place from a large exposure, it indicates decreased vascularity and decreased potential for success.
5. *History of pain:* If previously pain has not occurred in the tooth the potential for success is more.

## **MATERIALS USED FOR PULP PROTECTION**

Various materials are used to: (1) insulate the pulp, (2) protect the pulp in case of deep carious lesion, (3) act as barriers to microleakage, and (4) prevent bacteria and toxins from affecting the pulp.

### **Cavity Varnish**

In varnish, organic copal or resin gum is suspended in solutions of ether or chloroform.

Varnish liner is used for pulp protection and reduction of leakage. On drying, cavity varnish acts as an inert plug between the tooth and restoration.

In case of amalgam restoration, cavity varnish improves the sealing ability of the amalgam, reduces postoperative sensitivity and prevents discoloration of tooth by retarding ion migration into the dentin. If base is to be given or casting is to be cemented by zinc phosphate cement, varnish application is advantageous as it will block the seepage due to the available acid.

With restorative resins, cavity varnish is not used because the varnish liners dissolve in the monomer of the resin.

### **Cavity Liners**

Liners are thicker barrier than varnish used in conjunction with cement base. They have the same function as that of varnishes, to prevent or minimize microleakage. In addition, they also provide thermal insulation because they are thicker. Calcium hydroxide or zinc oxide eugenol are mostly used as liners. Currently, light activated glass ionomer and resin are also used as liners because of their ability to release fluoride.

### **Calcium Hydroxide and Mineral Trioxide Aggregate (MTA)**

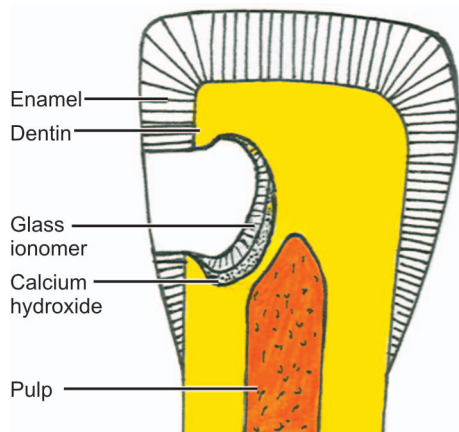
Calcium hydroxide or MTA is used as a liner, intermediary base and as direct and indirect pulp capping agent. The calcium hydroxide compounds are alkaline and have high degree of flow. Calcium hydroxide is bactericidal, so provides a sterile environment for the wounded and inflamed pulp to heal and to produce reparative dentin. Calcium hydroxide is water soluble and has low strength, so it must be placed on a dry tooth structure and a well sealed temporary restoration should cover it (Fig. 16.5).

### **Zinc Oxide-Eugenol**

It provides excellent sealing qualities and is bacteriostatic. It is used for intermediary bases and reinforced zinc oxide-eugenol is used for temporary restorations. The cement is helpful for relieving toothaches in case of deep cavities because of its sedative action. Zinc oxide-eugenol cement should not be used with composite resins as it inhibits the polymerization of the resin.

### **Zinc Phosphate Cement**

A thick creamy mix of zinc phosphate cement for luting castings or thick mix for basing is used to reduce the thermal conductivity of metallic restorations and to block the undercuts in the cavity wall in case of cast restorations. The thickness of the cement to provide effective thermal insulation should be at least between 0.50 to 1.0 mm. The cement should not cover on enamel wall or contact the cavosurface margin. If required,



**Fig. 16.5:** Class III cavity preparation in mandibular incisor with liner placed for protection of pulp. Glass ionomer liner is used in moderate carious lesion. Calcium hydroxide covered with- glass ionomer liner is placed in deep cavity

shape the cement with slow speed fissure bur or sharp explorer.

### **Polycarboxylate Cement**

Polycarboxylate bonds with the tooth structure and is biologically accepted by the pulp. It is used for the purpose of luting a casting or to be used as a base. Varnish should not be used with polycarboxylate cement because it would neutralize the adhesion potential of the cement.

### **Glass Ionomer Cement**

Glass ionomer cement have anticariogenic property because they continuously release fluoride throughout the life of restoration. They are also reasonably biocompatible with pulp. They bond to enamel and dentin.

The long-term success rate of pulp capping after carious exposure is low. Hence, direct capping of pulps

exposed in the excavation of caries should be avoided. Schuurs et al reported that the data currently available suggest promise for pulp capping with resin-based composites, but additional long-term research is needed before this method can be recommended. For detailed description of pulp capping Chapter 18 of the 'Textbook of Endodontics with MCQs' by the authors may be consulted.

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## *Periodontal Aspects of Operative Dentistry*

A restoration should be compatible both with the pulp-dentin organ and periodontal tissues. Periodontium consists of gingival, dentogingival junction, periodontal ligament and surrounding bone. Therefore if the gingiva is injured the adjacent tissues will also be traumatized. Normally the gingival margin is very thin, and there is no chance of deposition of food particle or debris. But once it gets inflamed then plaque and other debris can be accumulated very easily. If an instrument is forced inside the gingival sulcus it gets enlarged. At that time if a foreign material occupies the enlarged space, the space will not come to its original size and it will remain enlarged and viable for lodgment of other materials also.

If some disease process persists, the gingiva gets displaced from its own place and comes in an area near the contact area. Then the gingiva appears as saddle shaped. This condition is known as 'COL' shape. The 'col' gets covered with a tissue during the eruption of adjacent teeth, which is now called as reduced enamel epithelium. When atrophy of the facial and lingual papillae occurs along with gingival recession then the interproximal gingiva becomes convex in shape. In old age the gingiva gets recessed and then the concavities, facets on the tooth surface come into view. The sulcular epithelium is not very mobile like in other areas. So during tooth preparation if there is any sort of disturbance, it can injure the underlying tissues. The sulcular epithelium is alkaline in nature.

Facial and lingual gingival contours are made in such a way that it can distribute the food facially and lingually. In that way the gingiva gets massaged, circulation increases and protective keratinization is also increased. The functional forces from the occlusal surfaces of teeth should be directed along the long axis of the tooth, apart from the other functions such as incision, grinding and deflection. When the contact areas, the marginal ridges and the embrasures are properly restored they will help in maintaining oral hygiene in the following manner.

- a. Prevent the impaction of food in the interproximal area.
- b. Provide food streams which are capable of stimulating the gingival tissues.
- c. Maintain the mesiodistal width of the arch and prevent the tilting of teeth.

The periodontium is protected during lateral excursion because of disclusion mechanism. The amount of attached gingiva and depth of the vestibule should be sufficient for the health of the periodontium, and this is achieved by preventing the deposition of plaque and food particles at the marginal gingiva and by doing so they resist the penetration of these materials into the underlying connective tissue.

### **GINGIVAL CREVICE—PHYSIOLOGY**

The oral epithelium mainly protects the underlying connective tissue from various agents like bacteria, mechanical trauma, chemical poisons and heat injury. When the tooth erupts it breaches the epithelium layer, a bacteria resistant seal is achieved for the maintenance of protective function of the epithelium. This bacteria resistant seal is the epithelial attachment.

Junctional epithelium is that epithelium which joins the tooth. The attachment of the epithelium is called the "epithelial attachment". Though the epithelium is supported by circular gingival collagen fibers, mechanically it is weak. The junctional and crevicular epithelium is made up of such cells, which can renew themselves after 7 to 10 days. The cellular elements which are shedding are expelled to the sulcus. Hence, if those elements along with foreign substances have entered the sulcus they should be taken out in a proper way. This is known as expulsion. This is facilitated by chewing and by brushing of teeth, along with massage of the gingiva. The junctional epithelium if gets separated from the tooth surface can re-establish the

joint via the regeneration of epithelial cells which occur within a period of 6 to 10 days.

Diseases of the periodontium start and are continued by deposition of dental plaque on the teeth surface. Therefore, it should be kept in mind while making the dental restoration that it should not create any type of problem in the removal of plaque.

## **PERIODONTAL HEALTH CONCERN BEFORE DOING ANY RESTORATION**

Gingival sulcus depth is normally 1 to 2 mm buccally and lingually and 2 to 3 mm interproximally. After prophylaxis, i.e. scaling and root planing we have to wait for at least 1 month and then if we measure the pocket depth we find 0.5 to 1 mm gain in attachment, that means the probe penetrates 0.5 to 1 mm less than the previous depth. We also see 0.5 to 1 mm reduction in gingival recession.

Before doing any restoration the gingiva should be healthy. The gingival margin should be thin, and it should be tightly adapted to tooth and the papillae must occupy the interproximal space. The color of the gingiva is pale pink, melanin pigmentation may or may not be there. There should be no bleeding or no secretion on probing. Gingiva gets altered within 1 to 1½ months in case of gingival inflammation. If healing is completely achieved and mature collagen fibers are there then manipulation becomes easier and we can easily put the retraction cord for retraction of the gingiva.

## **EFFECT OF RESTORATION ON PERIODONTAL HEALTH**

Rubber dam should be applied prior to any restorative procedure so that any kind of trauma to the gingiva can be prevented. While preparing subgingival bevels it can cause some sort of injury to the surrounding soft tissues. But when the injury involves the junctional epithelium or it goes beyond the epithelial attachment, the injury is much more harmful and severe. Then the cementum which is injured is covered only by epithelium rather than connective tissue. In this case the periodontal support is lost forever. If the cavity is being prepared subgingivally the epithelium gets totally separated from the tooth surface. This can also happen in case of oral prophylaxis. But the epithelium gets attached to the tooth surface within 7 days.

## **Impression Taking and Electrosurgery**

The electrosurgery can be done while doing gingivoplasty, in the marginal gingiva. Electrosurgical needle enters into the bottom of the epithelial attachment. While cutting with this needle least tissue resistance is experienced, it is difficult to decide whether the needle is only at the bottom of the crevice or it is going deeper. Hence, electrosurgery inside the sulcus is not recommended.

In gingival hyperplasia electrosurgical needle can be used. In this area surgical dressing should be done. Impression should not be taken until the healing has occurred properly. All the surgical procedure where there are chances of exposure of the alveolar crest should be done before impression taking, because it causes resorption of bone.

## **Interim Restoration**

Subgingivally placed restoration often causes gingival irritation. Rough surface of the restoration facilitates the deposition of plaque. Temporary restoration should not touch the apical border of any preparation. Functional contact should be stable on the occlusal surface, otherwise it will lead to abrupt eruption of the teeth.

## **Margins of the Restoration**

If margin of the restoration is placed subgingivally it will lead to swelling of gingiva along with change in color. Mostly the subgingival irritation is related to the following conditions:

- a. When the restorative material used liberates some harmful substance
  - b. If the restoration attaches plaque on its surface.
  - c. If the restoration and tooth do not contact evenly.
- Phosphate cements and silicate cements show some sort of irritation.

The junction between the restoration and the tooth acts as a source of retention of the bacteria and plaque. For the following reasons the restorations has to be placed below the gingival margin.

- a. When the tooth fracture line is extending below the gingival margin.
- b. For esthetically perfect restoration.
- c. For better retention of the restorative material and the prevention of fracture of the restoration.

When the restoration is placed only supragingivally then the manipulation of restorations become easier.



Restorations placed below the gingival margin will cause inflammation of the gingival tissue. The degree of inflammation depends on the material and the contouring and finishing of the restoration. When the restoration is placed below the gingival margin the periodontal pockets increase in depth. There may be loss of periodontal attachment.

For better esthetics when the restoration has to be placed on the labial or buccal surfaces in the maxillary teeth, it should extend below the gingival level. As far as possible the restoration should not be placed more than 0.5 to 1 mm below the gingival margin. When the restoration is placed in the interproximal area, there will be inflammatory changes in the interdental papillae. Onlay should be prepared avoiding gingival third of the crown as far as possible.

### **Contour**

To prevent bruising and trauma and to provide proper stimulation to the gingiva from food during mastication correct contour of a restoration must be created. If the contour of the restoration is flat the gingiva becomes thicker. The gingiva adjacent to the normal contoured, shaped and properly finished restoration remains healthy and thin. Healthy and thin gingival margin is helpful in the maintenance of oral hygiene. Over contoured and under contoured both restorations are harmful to periodontium. Overcontoured restorations are much more harmful compared to the restorations that are very slightly under contoured. The over contoured crown or restorations will facilitate deposition of plaque substance. Any one of the following situations can change the normal shape of interdental space (see Figs 2.8 to 2.11).

- a. Overcontoured matrix band.
- b. Very bulky and over contoured cast restoration.
- c. Bigger pontics.

### **Contact Between Opponent Teeth**

If the occlusal contacts are not functionally acceptable then it may lead to accumulation of food and periodontal trauma. If food gets accumulated it will cause irritation of the periodontal tissues. It can be treated by

- a. Occlusal adjustment.
- b. Orthodontic treatment.
- c. By restorative procedures.

### **Post Restorative Care**

For good dental health plaque should be totally controlled. If a patient is having high caries index the patient should be instructed for regular dental check up and oral prophylaxis once in 3 months. But in other persons who are maintaining good oral hygiene by good home care, once in 6 months oral prophylaxis and dental check up is recommended. There will be deepening of pocket and loss of attachment if oral hygiene is not properly maintained. If attachment loss is 2 mm or more then treatment should be done.

During periodontal oral prophylaxis the following should also be done.

- a. Application of disclosing solution for better visibility of the plaque on the tooth surface.
- b. Patient should be reinstructed about the oral hygiene measures.
- c. Polishing of the tooth surface.
- d. Plaque and calculus below the gingival margin should be removed by a curette.
- e. Use of dental floss.
- f. Pockets around the tooth should be probed with a periodontal probe.
- g. Topical application of fluoride

### **OCCCLUSION AND PERIODONTIUM**

If the teeth are malaligned the periodontal tissues are also affected, then orthodontic and periodontal treatment should be undertaken along with the restorative procedure simultaneously, if possible. If trauma from occlusion is there, then also the periodontium gets affected. The excessive overbite impinges the mucosa and gingiva. If the periodontal damage is more, then it is necessary to bring back the stability, health and comfort. In order to achieve this properly contoured restorations have to be done (see Fig. 2.11).

### **Excessive Overbite Traumatize the Gingiva**

If the overbite is excessive the palatal gingiva of the maxillary incisors and the labial gingiva of the mandibular incisors get traumatized. If the posterior teeth are lost then the condition worsens. To treat this condition slight grinding and smoothening of the linguoincisor edge of the upper anterior teeth and labioincisor edge of the lower anterior teeth is done. The clinician should place his index finger on the labial surfaces of upper and lower anterior teeth and patient



## 168 Textbook of Operative Dentistry

is asked to do the lateral excursion movements. While doing these movements the finger should feel these movements very slightly and not excessively.

### **Tipped Molars**

If the lost lower first molar is not replaced then the following features are commonly observed.

- The mandibular second molar is tipped mesially and lingually.
- Gingival sulcus of that tooth becomes deeper.
- In the balancing side the interference is seen in the distobuccal cusp. The interference becomes prominent because the second molar has tipped.
- If a tooth is tipped severely then occlusal stability and better periodontal condition can be achieved by reducing the tooth mesially and by constructing semirigid fixed bridge. The crown has to be carved in such a manner that it will look like the original mandibular molar before the reduction and before tipping. For better retention deep lingual and labial grooves should be prepared in the crown restoration.

### **Splinting for Periodontally Weak Tooth**

To improve the functional stability and for better aesthetics splinting is done. If occlusal adjustment is done properly then the buccal and lingual mobility can be reduced. Tipped posterior teeth may cause the lodgment of food. So these can be treated by splinting of teeth. The upper teeth, where the periodontal support has been lost, can be treated by splinting. If the trauma is continuous and does not allow the teeth to function properly, then splinting is necessary.

### **Tooth Mobility**

Before doing any dental restoration teeth should be stabilized by periodontal therapy, occlusal adjustment and splinting.

## **FACTORS WHICH AFFECT THE PERIODONTIUM**

### **Caries**

As soon as decalcification occurs near gingiva the gingiva starts reacting to it. When the cavity is of larger size, the soft tissue gets much inflamed. As a result the periodontal tissues can show varieties of conditions,

like gingivitis, periodontitis. Where the lesion is near the gingival margin, all precautions should be taken to prevent injury to the gingiva during restorative procedure.

### **Separation of Teeth**

When separators are used it should be kept in mind, that the width of the periodontal ligament should be greater than the amount of separation to be achieved. But if the separation to be achieved is more in comparison to the width of periodontal ligament the periodontal ligament will be excessively compressed on one side and get torn on the other side. Therefore, the separation should be limited to the thickness of the periodontal ligament and never be done more than that.

### **Rubber Dam**

Rubber dam is used for isolation of the operating field. Carelessness in application of rubber dam can harm the periodontium. Under the following conditions rubber dam can be harmful.

- a. The rubber dam which is applied between the two septa can cause ischemia because of compression of the interdental papilla, facial or lingual papilla.
- b. When clamps are not used properly they injure the gingiva.
- c. When the dental floss is forced injudiciously.

### **Instrumentation**

During instrumentation the following can damage the periodontium.

- a. Excessive vibration causes tearing of the fibers of the periodontal ligament.
- b. Care must be taken while preparing gingival cavosurface margin to avoid laceration of the tissues.
- c. If there is excessive gingival recession near the cervical lesion the recurrence of caries can be prevented by free gingival graft or laterally repositioned flap.

### **Placement of Matrix Band**

Matrices and bands should not be irritating to the tissues. They should be made up of biocompatible material. They should have following properties.

- a. Well contoured for the mesial and distal as well as buccolingual sides.

- b. Well contoured on occlusal and gingival sides so that the part of matrix adjacent to the gingiva does not go beyond the apical part of the gingival sulcus. It should never press any portion of the gingiva or periodontal tissues between tooth and itself.
- c. On or after fitting it should never slip, apically and laterally. The slipping can cause tearing of the gingiva and contusion of gingiva as well as other periodontal tissues.

### **Retraction of Gingiva**

To avoid the damage during the restorative procedure to the periodontal tissues they must be retracted before doing any restoration.

- a. *Chemical methods:* Besides other methods there are two chemical methods and one electrosurgical method used for retraction of gingiva. Their effects on the periodontium vary.
  - i. The chemicals which cause constriction do not show any local effect on the tissues.
  - ii. Chemicals which have got the coagulant property cause inflammation of tissues. Coagulants which coagulate surface layer may cause severe type of inflammation.
- b. *Electrosurgical method:* For retraction electrosurgical methods are also used. They result in a tissue surface which is covered with a coagulum, along with tearing of gingiva to a certain extent. If inflammation is caused gradually gingiva returns to its original form and function by both primary and secondary intention.

### **Procedures Involved in Impression Taking**

While making cast restorations, the impression procedures, and the materials used in that procedure may irritate the periodontal tissues. Such situations are the following.

- a. When hydrocolloid and heat producing materials such as polymerizable impression materials are used for impression making.
- b. In some conditions where catalyst and derivatives of rubberbase elastomeric impression material cause allergy.
- c. Impression taking can also cause trauma to the surrounding periodontium.

### **Fabrication of Interm Restorations**

Periodontium may be injured due to following.

- a. If self-curing resin is used as a temporary restorative material then the excess monomer can cause irritation.
- b. During the time of polymerization, heat is produced to a larger extent, this heat can cause irritation.
- c. The cement used may be of irritating nature.
- d. When temporary restorations are being tried and adjusted inside the mouth.
- e. Due to carelessness during cementation of restoration some sort of irritation may occur. This irritation may lead to trauma to the periodontium.

### **Restorations**

The above mentioned trauma or irritation to periodontium may occur during any restorative procedure. The harmful effects will not last long if, the following conditions existed.

- a. The gingival tissues were healthy before treatment,
- b. The restoration provided favorable atmosphere for healing like good contact areas and contours.

The periodontium is affected by restorations in the following ways:

1. The facial and lingual surfaces if are overcontoured may act as a reservoir for food particles. As a result plaque gets accumulated and the food particles are deflected away from the gingival tissues. If the shape of a restoration becomes box shaped then the gingiva gets atrophied.  
The restorations should have a definite occlusal form. This occlusal form will help to direct the occlusal forces in a way parallel to the long axis of the tooth. This will allow the jaws to move freely during various functions and will help in mastication. If occlusal surface is similar as before it can push away the food particles from the contact areas. By discluding the teeth it also helps in protecting the periodontium from lateral loading (see Figs 2.8 to 2.11).
2. If the surface is polished properly it will be repulsive to the plaque substance. Soft tissues adapt themselves in a similar way to an unpolished and polished surface.
3. Overhanging restorations or underhanging restorations cause irritation to the gingiva (see Fig. 2.8).

4. If two dissimilar metals are used as restorative materials in the same oral cavity then galvanism occurs. This galvanism may cause atrophy of the surrounding gingiva.
5. Various restorative materials if in contact of gingiva may cause inflammatory changes in the gingiva in some individuals.
6. Some of the restorative materials or their constituents may cause allergy, redness and ulcers in the surrounding gingiva. These type of reactions are basically found with the alloys containing nickel.
7. Surface porosities sometimes may retain plaque and metabolic product and can be a source of irritation for the periodontium.
8. During the excess material removal from the gingival margin of the restoration the periodontium can be traumatized.
9. If the restorative particles show micro-movements it can traumatize or impinge the periodontium. If these movements persist for a longer period it can cause discrepancies and then favor plaque accumulation.

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Since 1850 dental amalgam has been used more than any other restorative material in dental practice. The dental amalgam alloys basically consist of silver, tin, copper and smaller amounts of zinc that are mixed with mercury. The alloy particles are wetted with mercury to initiate the physiochemical reaction and with time cause hardening as material sets. Early stages of reaction in amalgam are in plastic consistency which enable it to be inserted and condensed into the prepared cavity in the tooth and to recreate the normal anatomic contours. The first form of silver mercury paste was advocated by M. Taveau in 1826 at Paris. In United States, amalgam was introduced to the dental profession by the Crawcour brothers in 1833. They advertised it as a “Royal mineral succedaneum” or as a substitute of gold.

Dr. G.V. Black later carried out extensive and systemic experimentation with amalgam alloys and published a formula in 1896 as 68.5% Ag, 25.5% Sn, 5% copper and 1% Zn. This Black’s formula was altered, as high copper alloys were introduced. This improved the physical and clinical characteristics of dental amalgams. The high copper alloy contain by weight silver 45%, Tin 30.5%, Copper 24%, Zinc 0.5%. This alloy produces Gamma-2 free amalgam.

Many types of amalgam alloys are available. These alloys are selected on certified list of ADA specification No. 1. This specification is for silver amalgam alloy. The success of amalgam restoration depends on manufacturer and the operator. The manufacturer is responsible for product design and appropriate composition of metals in silver alloys, whereas the operator is responsible for (1) Material selection (2) Cavity preparation (3) Proportioning of the alloy/mercury (4) Trituration (5) Condensation (6) Carving and contouring (7) Polishing of restorations.

## **CLASSIFICATION, COMPOSITION AND CLINICAL CHARACTERISTICS OF AMALGAM**

Classification of amalgam is based in terms of:

1. Amalgam alloy particle size

2. Percentage of copper content
3. Zinc content.

In the early use, amalgam alloy was obtained by filing of silver coins into small particles which were mixed with mercury. This composition was inconsistent and did not produce a final amalgam with uniform properties. In late nineteenth century, Townsend, Flagg and others contributed to investigate the composition in relation with properties. However, better dental amalgam was developed by G.V. Black during the last decades of nineteenth century.

An efficient process was grinding the ingot of alloy typically on a lathe, and particles were known as lathe-cut particles. Lathe-cut particles were available in regular cut, fine cut and microfine cut and conventional amalgam alloys were commonly classified on the basis of particle size. Spherical particle alloys are packed more efficiently and require much less mercury to make a fluidity of the mixtures. In all spherical alloy particles, it is possible to reduce the mercury portion less than 50% by weight, whereas lathe-cut alloys having more surface area require more mercury, as much as more than 50% by weight.

During the middle of the twentieth century, researches on the benefits of increased copper content in amalgam alloys confirmed the better physical properties, which prevented the intraoral corrosion. The percentage of copper content is the main system in use today, as the basis of classification of dental amalgam alloys. High copper alloy produce amalgam which is free from corrosion-prone and weak gamma-2 phase, thereby producing durable restorations with a lasting luster.

Another metal combined to amalgam alloy is zinc. Generally, zinc is added in conventional alloy to suppress the oxidation of the key elements of the alloys. Zinc containing alloys have the side effect that moisture contamination prior to setting, leads to the formation of ZnO and produces hydrogen gas that expands the amalgam excessively, resulting in pain. Some manufacturers also produced non-zinc amalgam alloys for the filling where the isolation was difficult, but the zinc has some beneficial effect on longevity of amalgam.

## 172 Textbook of Operative Dentistry

So, amalgam alloys containing zinc and non-zinc containing alloys are manufactured.

Composition and structure of amalgam alloys have great effects on their clinical characteristics. Restoration of certain teeth having characteristics of amalgam are advantageous while in some, teeth restorations are early failures. For details on composition and structure refer 'Textbook of Dental Materials with MCQs by the authors'.

### PRINCIPLES OF CAVITY PREPARATION FOR AMALGAM RESTORATIONS

There are many common design features in cavities for most restorative materials. These features are related to integrity of cavosurface margins, adaptation of restorative materials to walls and margins, minimum depth of the cavity, retention of the restoration, removal of carious lesions with protection of pulp. Depending on the properties of restorative material the cavity is modified accordingly. The compressive strength of amalgam is poor hence in thin layers it will fracture under masticatory forces. Therefore, thin margins and layers of amalgam must be avoided where they are exposed to masticatory forces.

#### Outline Form

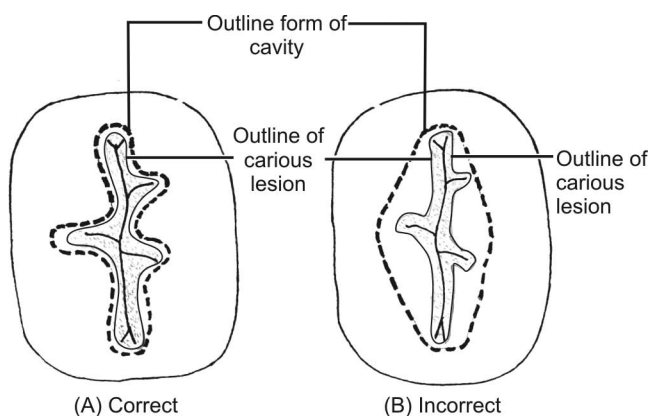
Outline form is "the area of the tooth surface to be included within outline of the cavity". Actually, outline is to be termed as external and internal outline. The outline form includes the needs for extension for

convenience. Outline form of the prepared cavity is approached beginning at some central position of tooth surface, for example penetrating the burs into carious occlusal surface, extending laterally to establish outline. External outline form consists of smooth curves, straight lines and rounded angles. Conservative removal of caries using rotary instruments permits triangular cusp ridges to remain intact (Figs 18.1 and 18.2). Occlusal cavosurface angle should be between 85 and 95 degree. All unsupported enamel rods must be removed.

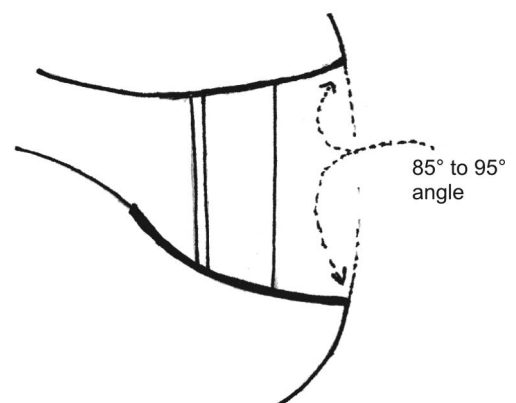
#### Reverse Curve

On occlusal surface a reverse curve taking the form of a concave curve is used as a means of conserving the sound tooth tissue, which preserves the triangular ridge of the affected cusp. Flare of the proximal wall leaves the tangent to that outer tooth surface at almost right angles (85° to 95° angle) that creates maximum resistance form for the tooth and restoration. The reverse curve is a design feature in cavity preparation for proximo-occlusal amalgam restoration which occurs as a means of preservation of tooth tissue (Fig. 18.2).

The inner dimensions of the prepared cavity design reflect the geometric penetration of the carious lesions. Unnecessary loss of tooth tissue is to be avoided. Adequate thickness of amalgam restoration should be attained for strength. Axial walls are positioned uniformly into dentin. Depth of proximal dentinoenamel junction is slightly greater than diameter of bur used. Axial wall in an occlusogingival direction is usually a

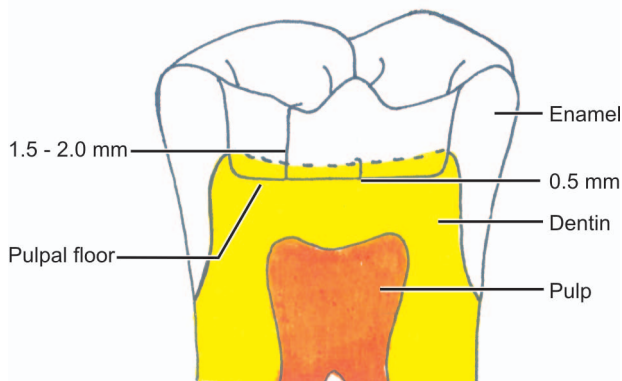


**Fig 18.1:** Outline form of a class I cavity in first mandibular molar



**Fig. 18.2:** Reverse curve in occlusal outline of proximal cavosurface margins in posterior teeth





**Fig 18.3:** Position of occlusal pulp floor, is at least 0.5 mm deep within dentin and devoid of enamel providing a minimum vertical thickness of 1.5 to 2.0 mm of amalgam

flat plane, parallel or slightly divergent with the axis of the tooth from occlusal to gingival in posterior teeth. Minimum buccal-lingual dimension of axial wall is dependent on the external outline of buccal and lingual proximal margins (Fig. 18.3).

### Resistance Form

Resistance form is that shape given to a cavity intended to afford such a seat for filling as will best enable it to withstand the stress brought upon it during mastication. The pulpal and gingival walls are prepared flat with slightly rounded angles. The pulpal and gingival walls should be perpendicular to the long axis of tooth.

### Retention Form

Retention form is, “preventing the filling from being displaced”. In most of the cavities retention form is made by shaping of the opposing walls strictly parallel or slightly undercut, so that the filling will be retained firmly. Inversely tapered walls of the proximal box have been long standing principles of retention. The proximal retention to resist the horizontal components of masticatory forces tending to unseat the proximal boxes from the axial wall is widely used. The buccal and lingual proximal walls require divergence to produce sound margins and grooves within proximal dentin walls to functional principles of retention form. On the occlusal surface, preparation as dovetail is done to produce retentive features for proximo-occlusal restoration to resist proximal displacement.

### Convenience Form

It is the part of the shaping of the cavity that renders the form more convenient for removing the caries and placing the filling materials. It is required for instrumentation, to remove the defects, cavity refinement and restoration placement. Especially for amalgam restoration it is the form or shape that also permits access of condensing instrument, smooth curves and rounded angles of external outlines.

### Removal of Remaining Carious Dentin and Pulp Protection

After establishing the internal and external outlines, caries removal begins by extending laterally at the pulpal floor depth. Small carious portion is completely removed by establishing conservative external and internal outline form. Deepening of the entire pulpal floor or axial wall beyond that required for resistance and retention form is not required. All sound tooth tissue should be retained.

Removal of carious dentin establishes outline, resistance, retention and convenience form only in the order of procedures. Sequence of procedures will provide better opportunity for retention and resistance of the restoration.

### Finish of the Enamel Walls and Margins

The enamel wall and amalgam interface should form 90 degree angle butt-type junction of the tooth tissue and amalgam restorations. Amalgam of greatest bulk provides maximum strength. Finishing of the enamel walls and margins should adhere to the restoration in paralleling the enamel rods at dentinoenamel junction. Finishing of walls and margins is guided by the knowledge of histological structures of tissues.

The preparation of obtuse and acute cavosurface angle of enamel if unsupported by healthy dentin will decrease the life of restorations. In permanent teeth on axial surface, enamel rod direction near cemento enamel junction declines apically. The final direction and finish of the walls occurs as external outline form in the area is completed.

### SECONDARY (ADDITIONAL) RESISTANCE AND RETENTION FORM

If from clinical judgement it has been observed that sufficient resistance and retention is not present in tooth

## 174 Textbook of Operative Dentistry

preparation than secondary resistance and retention is provided in the form of grooves, locks, coves, pins, slots and amalgam pins to increase the retention form. The increase in retention form also increases the resistance form. Bonding of amalgam also increases the retention and resistance form but it is not a substitute of the primary mechanical retention. The requirement of these secondary resistance and retention form is more in larger cavities.

### Final Procedures

Before restoration, the cavity preparation is examined from all angles to ensure the following:

- a. Complete caries removal
- b. Proper depth
- c. Correct angles between cavity preparation and amalgam
- d. Absence of any debris.

### DESIGNS OF CAVITY PREPARATIONS

Commonly made cavity preparations for amalgam are called 'Conventional' cavity preparation. Other class II types are 'box only' or 'slot only' and 'tunnel' cavity preparations described in chapter – 8.

### CAVITY LINERS, VARNISH AND BASES FOR AMALGAM RESTORATIONS

Following cavity preparations, enamel and dentin surfaces which are present inside the cavity are covered with a layer of tenacious debris known as smear layer. Also in temporary restoration of ZnO-eugenol, a thin film also remains present after removal, and it may interfere with the physical characteristics of restorative materials or their adaptability to the cavity walls.

Many of the restorative materials have excellent properties but may not protect the dental pulp during setting or at the time of thermal cycling due to eating hot and cold foods or masticatory stress. The pulpal protection requires chemical, electrical, thermal and mechanical protection with pulpal medication. The liners and bases are those materials which are placed between dentin and restoration and provide pulpal protection. Protective needs for tooth and restoration vary from place to place and on which type of materials are used for restorations.

### Cavity Liners

Liners are thin layers of material used to provide a barrier in protection of dentin and pulp. They are a liquid in which  $\text{Ca(OH)}_2$  and/or ZnO are suspended in solution of natural or synthetic resins to minimize the potential effect of the restorative material on the pulp. They are soluble and should not be placed on the cavosurface margins.

### Bases

Bases function as a barrier against chemical irritation, prevent thermal conductivity and supplement mechanical support for restorations. Mechanical support is required to protect the disruption of thin dentin over pulp during restorative material condensation procedures. Examples of these materials are ZnO-eugenol, Zinc-phosphate, Zincpolycarboxylate, GIC and some commercial preparation materials containing calcium hydroxide. A cement base material is also used in cavity to restore the internal outline. These materials not only have a low thermal conductivity, but also have a high compressive strength and stiffness. The selection of bases for amalgam restorations are based on two points, (a) strength to support the forces of amalgam condensation and (b) to strengthen the restoration under masticatory load. The strength of the bases depends upon the size, thickness and mechanical properties of base, cavity design, position and amount of load.

Intermediary base is a material used in cavity, as a protective barrier or provides some therapeutic benefits to tooth and restorations. These materials are  $\text{Ca(OH)}_2$  and ZnO-eugenol. In a cavity when pulpal floor and axial wall are of sufficient depth to provide an adequate thickness of amalgam and remaining dentin thickness is maximum, resinous film forming varnish is used in two or more coats on dentin and enamel walls to minimize the microleakage at the interface of tooth cavity and restorations. The varnishes are natural or synthetic resins dissolved in ether or chloroform. During lining, solvents evaporate, leaving a thin film on cavity. When restorative materials, either a composite or unfilled resin come in contact with varnish, resin polymerization is inhibited and it remains soft. The varnish-resin interface weakens the strength of resin restorative materials.

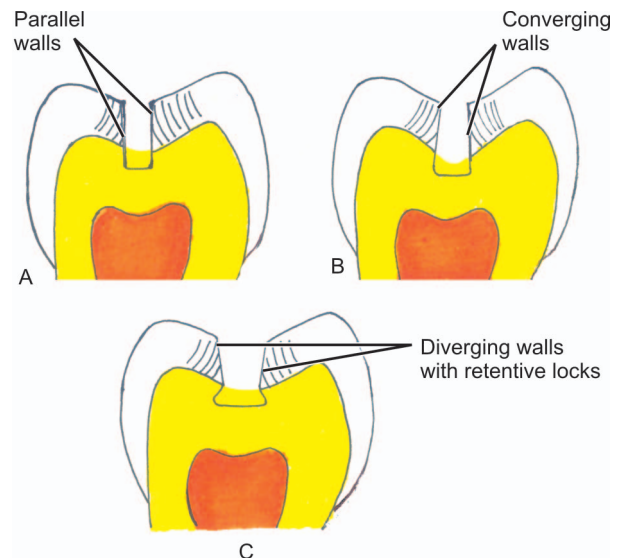
## AMALGAM RESTORATION FOR CLASS I CAVITY PREPARATIONS

Amalgam is most common material used for restoration of Class I cavities.

The outline form for Class I cavity should include all the occlusal pits and fissures in such a manner that sharp angles in the outline are avoided. Class I cavity preparation is started by entering the deepest or most carious pits using a round carbide bur at high speed with air water spray. The long axis of bur is held perpendicular to the plane visualized for pulpal floor. The bur enters the pits, proper depth of 1.5 to 2.0 mm should be established. The depth is measured from the central pit.

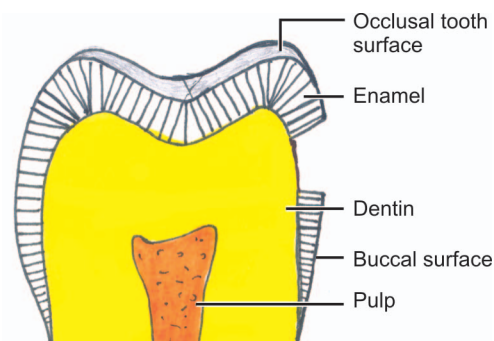
A round bur is selected for penetration and extensions for various reasons, i.e. resulting in less bur blade fractures and air-water spray coolant will prove more effective at this stage, and use of enameloplasty may be considered. The position of external and internal outline is initiated, pulpal floor is positioned, the fissures are removed. Central fissures approximate the lingual surface which is seen in mandibular first and second premolars. The buccopulpal and linguopulpal line angles are rounded.

The plain fissure bur no. 57 provides extension of internal and external outline, extension of occlusal wall to attain the dentino-enamel junction, flatten the pulpal floor, tapering of occlusal walls adjacent to marginal ridges, finishing the enamel to coincide with enamel rod directions. As straight fissure bur enters the opened preparation each time it should be realigned. It is assumed that caries has progressed along the dentino-enamel junction and requires such an extension to establish that junctions are intact. Cavity preparation includes complete removal of the remaining defective and infected enamel dentin, pulp protection, finishing procedures for external walls and final cleaning with ideal depth (Fig. 18.4). Retention is placed into longer dentin wall. Preparation should be made by the operator to evaluate the principles of design. Refinishing may be required using a straight fissure bur. Preparation for



**Fig. 18.4:** Class I Division 1 preparation of occlusal enamel wall from pulpal floor to occlusal surface depends upon the removal of all unsupported enamel rods or to be parallel with the enamel rod direction [A] Parallel walls [B] Converging walls, [C] Diverging walls

Class I carious lesion on different teeth and surfaces follows the same principles where the size of bur should be reduced in smaller size of teeth (Fig. 18.5).



**Fig. 18.5:** Class I Division 2 cavity preparation on buccal pit of mandibular molar for amalgam restoration

### Cavity Preparation on Occlusal Surface with Buccal or Lingual Extension

Modification of Class I occlusal cavity in posterior teeth for removal of caries from buccal or lingual fissure and/

or pit is done. Extension of the pulpal floor in the same plane may include the lesion. For this a box is formed with mesial and distal walls parallel with retention grooves placed in the walls. The depth of the axial wall must be sufficient for placement of retention groove into dentin and permit appropriate condensation within the box itself. Careful inspection of preparation is needed to evaluate the need of additional cleaning and additional finishing. Irregularities at the margin indicate weak enamel that should be smoothed by rotating bur at slow speed.

### Cavity Preparation on Buccal and Lingual Pits

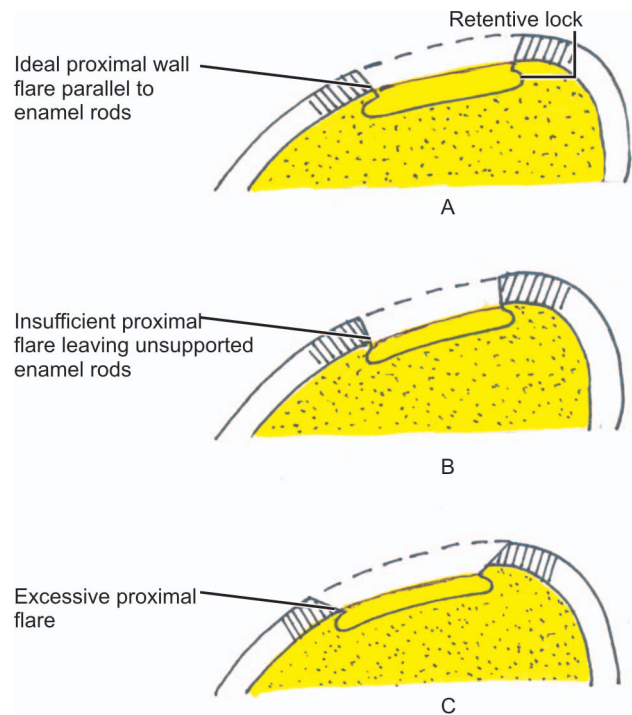
Class I cavity on pits of buccal and lingual surface of maxillary and mandibular molar varies in technique but not in principle from those of occlusal surfaces. Axial wall must be of sufficient depth not only for strength of amalgam, but also to allow for retention. This wall will vary in depth from occlusal to gingival.

Direction of rods surrounding the anatomic pits is extremely variable. Rods are observed to form continuously changing angles from gingival to occlusal. On occlusal wall surface, greater obtuseness is required of cavosurface angle in order to parallel the direction of the rod. Preparation outline is governed by the extent of caries and is generally conservative.

### AMALGAM RESTORATION FOR CLASS II CAVITY PREPARATION

Class II restoration involves the proximal (mesial or distal) surfaces of premolars and molars. It constitutes one of the largest groups of cavities restored with dental amalgam. Class II cavity involves at least two surfaces as mesio-occlusal (MO) or disto-occlusal (DO).

The usual position for the beginning of lesion is cervical or apical to the contact area with the adjacent tooth. The penetration into the carious lesion and its removal and cavity development should be from a buccal, occlusal or lingual direction. The approach is made on the basis of conservation of sound tooth tissue, convenience and esthetics. Class II cavity preparation begins identical to Class I preparation as entrance through occlusal surface that permits caries removal only in the marginal ridge area just occlusally from the proximal surface (Fig. 18.6).



**Fig. 18.6:** Horizontal section through class II division 1 or 2 cavity preparation for amalgam near the cervical floor on maxillary first molar. [A] Proximal walls flare parallel to enamel rods, ideal flare, [B] Proximal walls flare leaving unsupported enamel, insufficient flare, [C] Excessive proximal walls flare causing difficult condensation and weakened margins of amalgam restoration

Using high speed bur with air-water spray, on occlusal surface enter the pit which is nearest to involved proximal surface, with the long axis of the bur parallel to the long axis of the tooth. Proper depth of initial entry cut is around 2.0 mm, including the pulpal dentin. Move the bur, extend the outline to include the central fissure, the isthmus width should be as narrow as possible, but not wider than one fourth the intercusp tip distance. Pulpal floor should be prepared to uniformity. On occlusal surface, facial, lingual and proximal walls (in caries free side) are made with a slight occlusal convergence which provides favorable amalgam angles at margins. Enameloplasty should be utilized to conserve tooth structure. Before extending into proximal marginal ridge, visualize the proximal box relative to contact area, as this will prevent the over extension of the occlusal outline form. Initial procedure in preparing the outline of the proximal box, isolation is necessary in conservative cavity preparation. The end of the bur cuts gingivally along the



exposed dentino-enamel junction at the expense of two-third dentin and one-third enamel, extending gingivally just beyond the caries or the contact width.

Facial and lingual extension, visualize the completed margins as right angle projections of facial and lingual limits. The finish of the gingival margin will be only slightly above the gingival margin to avoid the possible contributory factor to periodontal diseases. The proximal cutting is sufficiently deep into the dentin (0.5-0.6 mm) so that retentive locks are prepared into axiolingual and axiofacial line angles. The proximal cut is diverged gingivally. Faciolingual dimension at the gingival surface is greater than the occlusal surface. Gingival divergence will provide good retention, conserving the marginal ridge.

The bucco-lingual position of the proximal box relative to occlusal portion of the prepared cavity results in change in direction of outline form at the junction of proximal box and occlusal isthmus. This change is known as “reverse curve” (Fig. 18.2). While the proximal enamel extension is allowed to remain intact, chisel is used to clean away the unsupported proximal enamel and finish the enamel walls and margins. Removing any of the remaining enamel and carious dentin on pulpal wall in Class II preparation is accomplished same as a Class I preparation.

‘Slots’ in the gingival floor may be used to provide additional retention in an extensive proximal box. ‘Pot holes’ in the gingival floor may also provide additional retention. An improper axiofacial or lingual line angle must not be used as a guide for proximal lock. Class II amalgam restorations are related to creep value of the amalgam alloy. Higher the creep value, greater the proximal extrusion or marginal breakdown. The proximal retentive locks as well as amalgam with low creep value, should be used to maximize the strength of restoration. High copper amalgam today satisfies this requirement; it is recommended that creep value of amalgam should not exceed 1%. During final preparation of cavity it should be cleaned with air/water spray or with cotton pellet. Inspect the cavity for detection and removal of debris and examine for correction of all cavosurface angles and margins.

### **Incipient Class II Amalgam Restoration**

Incipient lesions are small in area and lie immediately below the anatomic contact point. In the malpositioned

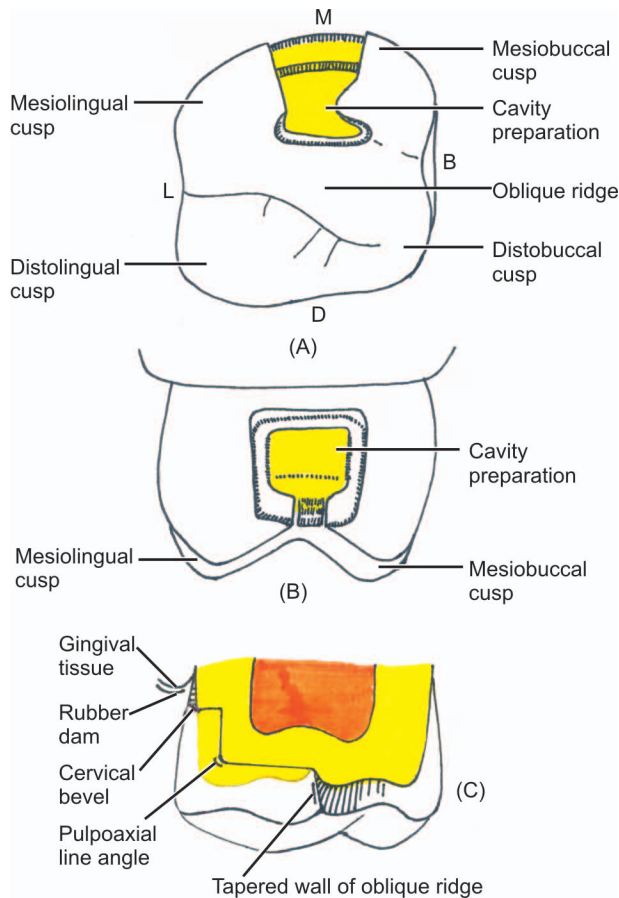
teeth, actual point of contact lies elsewhere, which in turn alters the location of the lesion. Detection of incipient caries is most easily done by bite wing X-rays. In general, the outline should be small and conservative. The cavity is sort of an inverted slot on the side of the tooth, the gingival wall is parallel and extends below the lesion into the enamel (usually below the contact point). Location of facial and lingual margins is determined by extent and character of the enamel. The location of these walls is determined by the clearance between them and proximal surface of the adjacent tooth. The sharp, clean-cut walls form cavosurface margins that are 90 degree throughout depth of cavity and are equal in all areas. Enamel unsupported by dentin is removed (Figs 18.7 to 18.10).

The axial walls are flat or slightly convex and almost parallel with the long axis of tooth. The facial and lingual walls have slight undercut to retain the amalgam. These undercuts are not deep and extend from gingival floor to occlusal surface. In the axial wall, grooves are prepared for necessary marginal refinement along the occlusion.

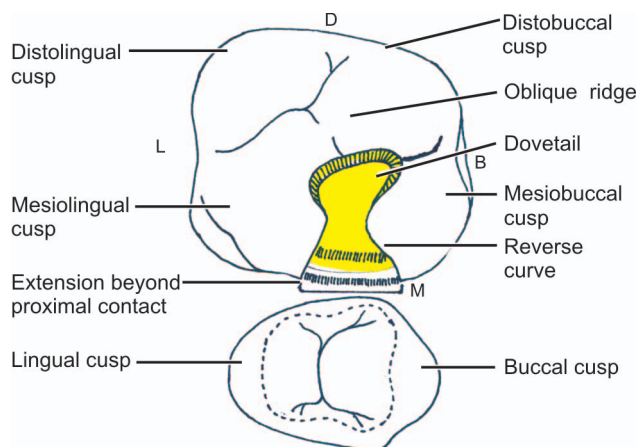
### **Amalgam Restoration in Extended Class II Cavity**

Extended amalgam restoration is larger because of larger cavitated area or due to recurrent caries around the existing restoration. For additional retention retentive locks (parallel to the long axis of tooth) are prepared. (Figs 18.10 and 18.11). The size of extended restoration depends on needs of a situation. If the caries undermines the enamel along the gingival border, the floor must be extended rootward to eliminate the unsupported enamel. The extent of caries on facial and lingual surface determines the width of cavity preparation. These walls are prepared more or less flat and straight with their cavosurface angle at 90 degree. The successful execution of the box preparation is directly dependent upon the accuracy and exactness with which undermine groove has been made. One must carefully judge that the corners are sharp and clean-cut and locks (slots) that have been sufficiently extended towards facial and lingual walls with grooves are flat and smooth on gingival floor. The operator should assure that the slot (locks) have been properly made (Figs 18.11 and 18.12).

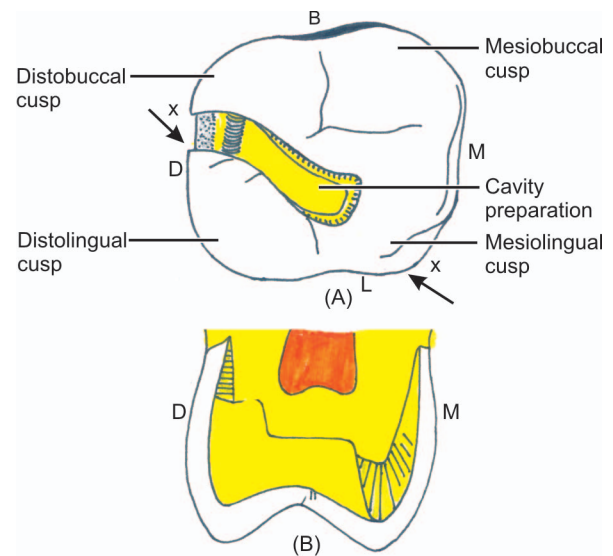




**Fig. 18.7:** Maxillary first molar showing class II Division 3 cavity preparation for amalgam [A] Cavity from occlusal view, [B] Cavity from mesial view, [C] Cavity in mesiodistal section SIDES-B=Buccal, L=Lingual, M=Mesial, D=Distal



**Fig. 18.8:** Occlusal view of first maxillary molar (cavity class II division 3) showing proximal margins extending conservatively beyond the contact area with the adjacent tooth

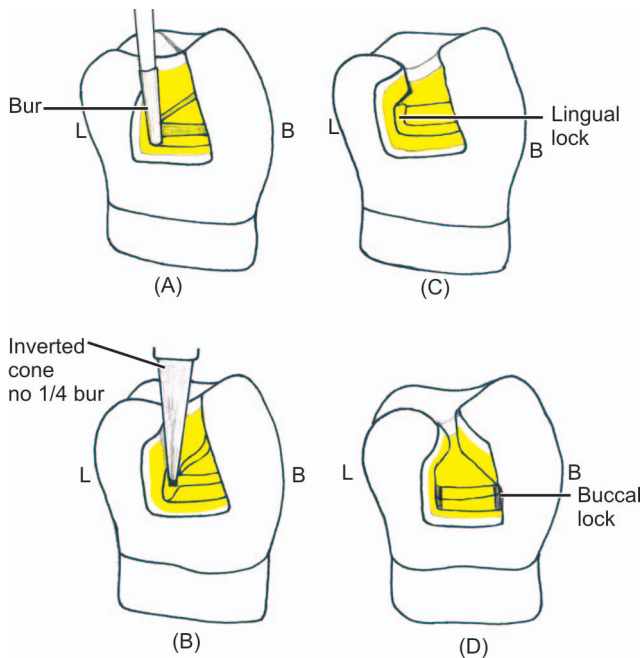


**Fig. 18.9:** Maxillary first molar showing conservative class II division 4 cavity preparation for amalgam (M= mesial side D= distal side). [A] Occlusal view, [B] Distolingual view of section at axis xx' as shown by arrow in [A] through the cavity. Conservative cavity preparation is indicated in persons with very low caries susceptibility



**Fig. 18.10:** Mesial enamel wall unsupported by dentin. Such wall is removed for Inlay and amalgam filling. For composite and GIC filling such wall is preserved

The margins are planed with hand instruments. Prior to use of the hand instruments their cutting edge should be tested. The primary function of cutting instrument is to plane and smoothen margins in proximal box areas. The classic area where access may be overlooked is in the bucco-occlusal area called reverse curve (Fig. 18.2).



**Fig. 18.11:** Preparation of proximal retention locks in MO or DO class II division 3 or 4 [A] Position of no. 169L bur retentive lock is prepared by moving the bur lingually and pulpally, [B] Lingual lock being prepared [C] Prepared lingual lock [D] Prepared buccal and lingual locks. L=Lingual surface, B=Buccal surface

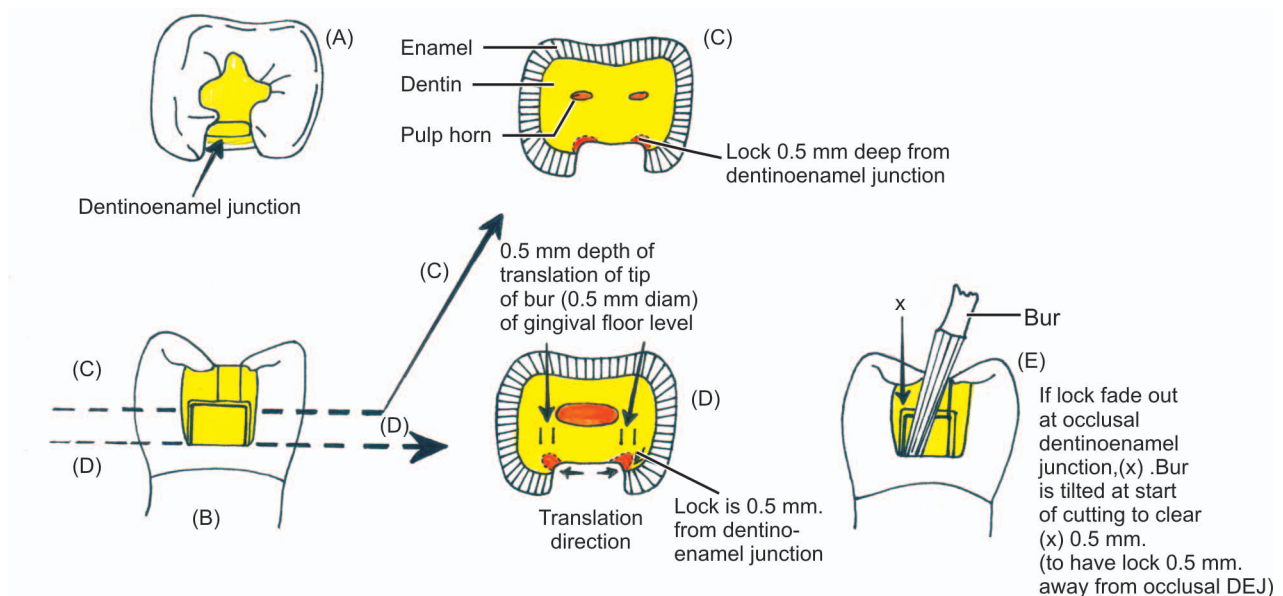
Internal refinement of a cavity is a matter of routine inspection of areas such as depth of cavity or refining the occlusal wall or a line angle. It is felt that angular retentive groove enhances the retentive properties of the amalgam restorations. Examine for debris, walls and remaining carious dentin. The peripheral walls should be smooth. While removing the debris if the cavity is extended, chances of pulp exposure are much more. Select the bases/liners for protection of pulp under a deep-seated restoration.

### CLASS II SLOT CAVITY PREPARATION

Among the conservative cavity preparations, besides 'box' and 'tunnel' preparations 'slot cavity' preparation is also getting popular for the patients who have following conditions (Fig. 18.13).

- have proximal contact intact as caries lesion is below the contact area.
- have very low caries susceptibility index.
- are very much scared of cutting.
- expected life of the tooth is not more than 5 years.

In this the carious lesion is approached through the occlusal, buccal or lingual surface as the adjacent tooth is also present.



**Fig. 18.12:** Placement of retentive locks in mesio-occlusal preparation. [A] Occlusal view before preparing retentive locks, [B] Proximal view, [C] and [D] Position, depth and translation of retentive lock, [E] Proximal orientation

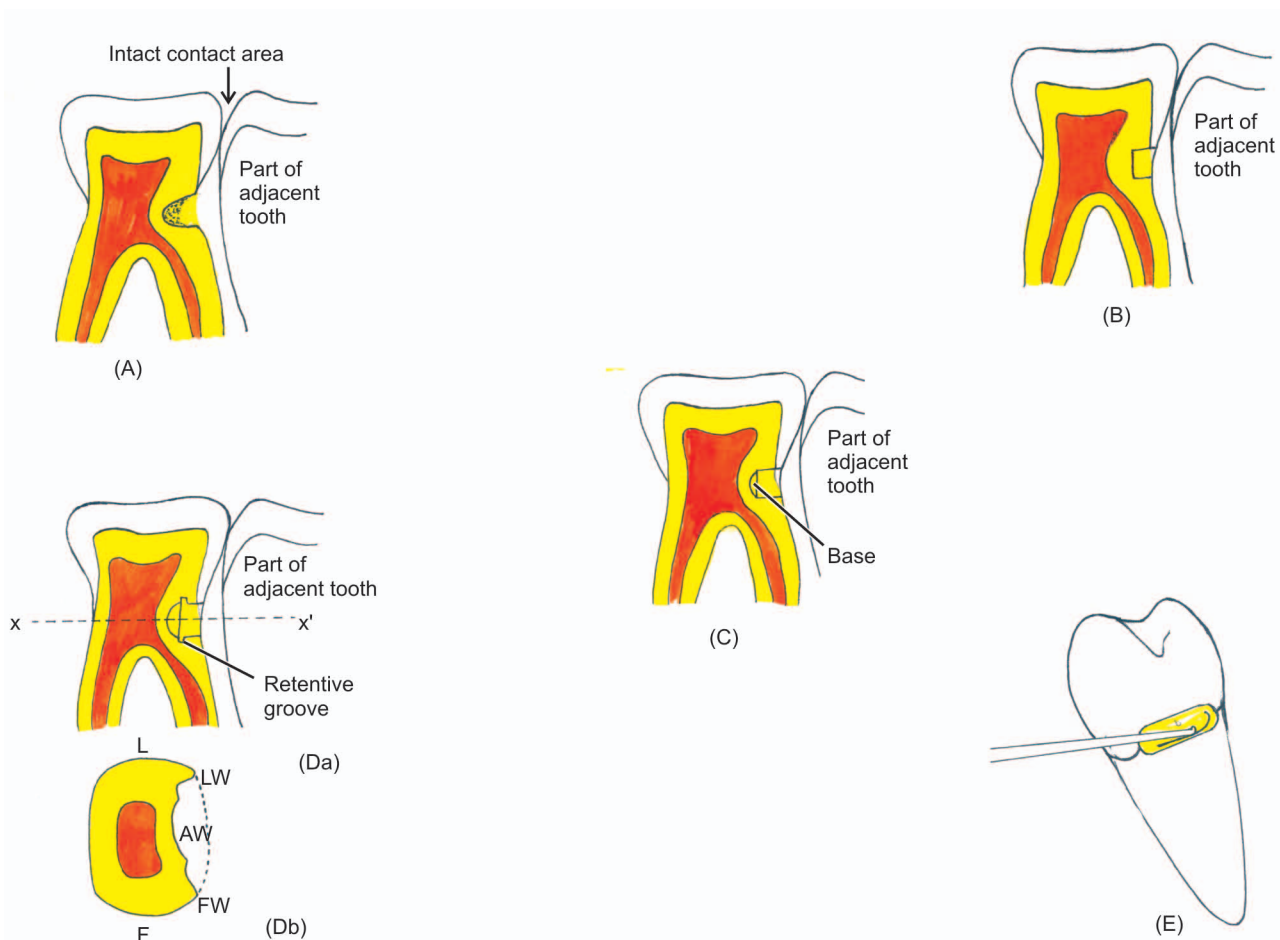
## CAVITY PREPARATION INVOLVING BOTH PROXIMAL SURFACES (MOD)

The MOD cavity preparation follows the same sequence as two surface cavity preparation. According to modified Black's classification, when two Class II lesions on the same tooth that are restored with a single restoration is termed as MOD preparation and is classified as class II division 5 (Figs 18.14 and 18.15).

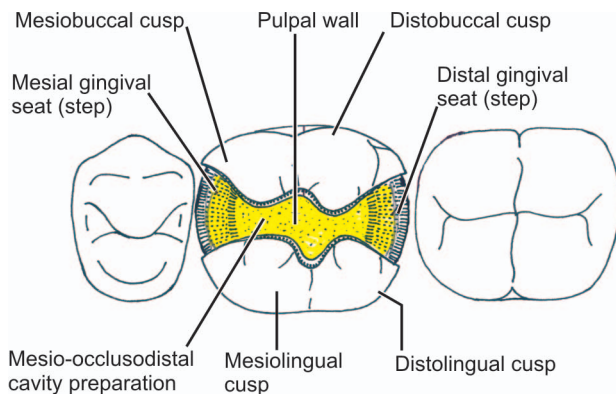
In the mesio-occlusodistal (MOD) cavity preparation the mesial, distal and occlusal surfaces are involved. The procedures for cavity preparation in the mandibular first molar distal cusp present a problem when positioning

the disto-facial wall and margin. Facial extensions on the disto-facial margins to clear the distal contact, place the occlusal outline in the center of cusp. This relocation of margin provides a sound enamel wall. When distal cusp is small or weakened, extension of distal gingival floor and disto-facial wall places the margin just mesial to disto-facial groove to include the distal cusp.

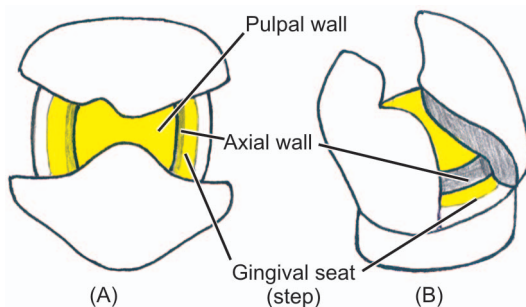
In maxillary molars, cutting of oblique ridge is indicated only in following conditions. (a) Ridge is undermined with caries, (b) Ridge is crossed by a very deep fissure, (c) If occlusal portion of separated mesio-occlusal and disto-occlusal outline forms leave less than 0.5 mm of tooth structures between them.



**Fig. 18.13:** Mesiodistal longitudinal section of tooth showing slot preparation. [A] From lingual or buccal approach carious lesion is seen without involvement of proximal contact, [B] Primary cavity preparation, [C] cavity preparation and application of base after removing infected carious dentin, [Da] Longitudinal section showing retentive grooves, [Db] Transverse section through plane XX' showing direction of facial wall (FW) and lingual wall (LW) and contour of axial wall (AW) [E] Preparation of retention form to complete cavity preparation



**Fig. 18.14:** Occlusal view of a mesio-occlusodistal (MOD) class II division 5 cavity preparation for amalgam on a mandibular right first molar



**Fig. 18.15:** Mesio-occlusodistal class II division 5 cavity preparation for amalgam in mandibular second premolar. (A). Occlusal view (B). Proximo-occlusal view

## AMALGAM RESTORATION IN CLASSES III, V AND VI CAVITY PREPARATIONS

### Class III

Class III cavity preparation for amalgam are most common in the distal surface of maxillary and mandibular canines. For esthetic reasons, amalgam is not indicated for proximal surface of incisors and mesial surface of canines.

The class III cavity is a smooth surface lesion. Usually outline form includes only the proximal surface. A no. 2 bur with air-water spray penetrates through enamel on distolingual marginal ridge. The bur is held so that its long axis is perpendicular to the lingual surface of the tooth. The extension is completed when facial, gingival and lingual walls are formed. The corners of cavity form are rounded to accept the restoration. The dental caries, direction of enamel rods and convenience

form determine the final outline. Proximal box having a triangular and retentive groove incisally and cervically constitutes a conservative cavity preparation. Cavo-surface angle should be about  $90^\circ$  at all margins, axial wall should be uniformly deep into dentin. Final cavity preparation involves the removal of any remaining infected dentin, pulp protection, developing retention form and finishing the external walls.

Lingual dovetail is not required for small sized class III cavity preparation. It is needed for large preparations, those on excessive incisal extension in which extra retention is necessary. Lingual dovetail is prepared only when the preparation of proximal portion is completed because tooth structure needed for isthmus between proximal portion and dovetail might be removed when the proximal outline form is prepared. In class 3 cavity preparation, bur is directed through lingual marginal ridge and bur is directed parallel to the proximal surfaces. For the reason of poor esthetics amalgam is usually not used for class III cavity.

### Class IV Restoration

Amalgam is not used for class IV restorations because of poor esthetics, edge and compressive strengths.

### Class V Cavity Preparation for Amalgam Restoration

Cavity on the gingival third of facial and lingual surfaces of all teeth are class V cavities. Anterior teeth are very rarely restored with amalgam except when esthetics is of no concern, for example in very aged patients. The cervical caries usually develops when the tooth surface is unclean. The outline form of these lesions is dictated by the extension of caries process, abrasion and erosion. During cavity preparation, maintain uniform cavity depth and develop butt joint throughout. Retention is expressed as undercuts occlusally and gingivally. Mostly outline form is of kidney shape.

A round bur of suitable size is used with high speed to establish the outline form. The axial wall depth at the occlusal wall is more than at the gingival wall. A curved axial wall is formed and this approximates the contour of the pulp organ.

The walls of the mesial and distal surfaces are prepared perpendicular to the outer tooth surface, paralleling the direction of enamel rods. The occlusal wall is tapered towards the occlusal cavo-surface margins



## 182 Textbook of Operative Dentistry

to form an obtuse angle of the enamel. Retention form is established in dentin of the cervical and occlusal walls to approximate depth (Figs 18.16 to 18.19).

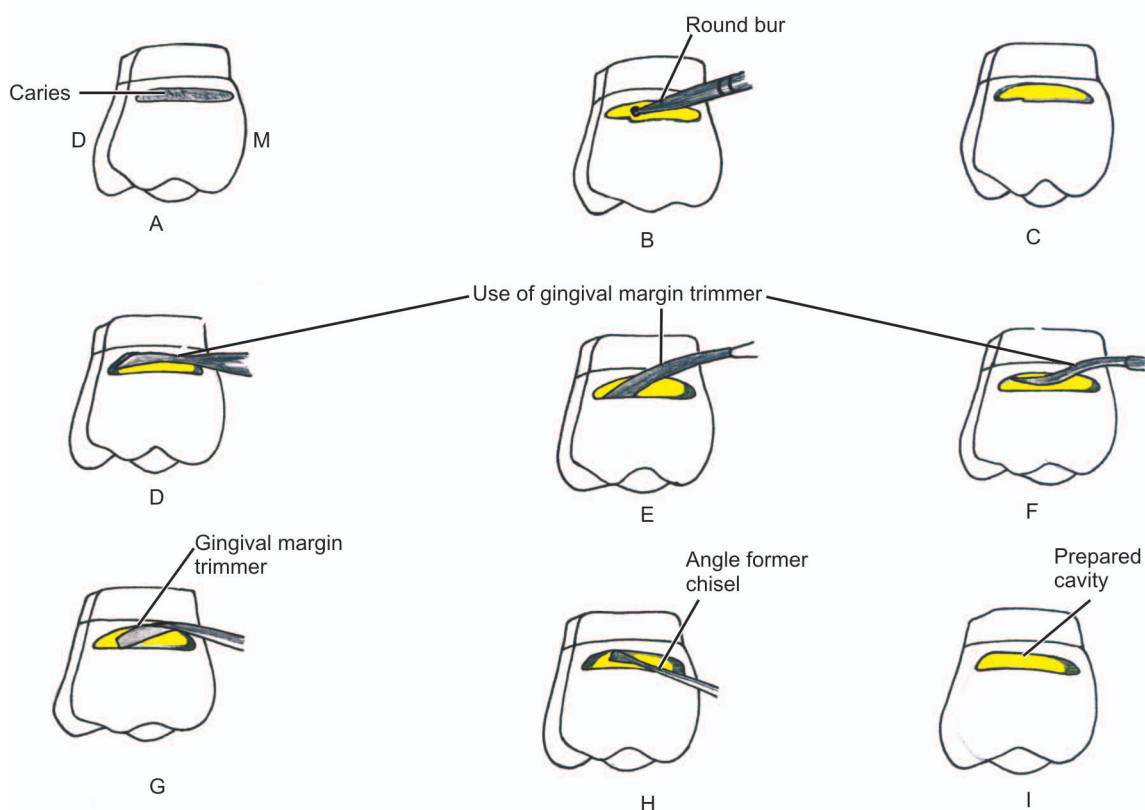
In some cases, the defective enamel extends beyond the corners of tooth into the proximal surface of previously placed amalgam restoration, the cavity extends into adjacent restoration. Since the axial wall is not receiving the direct force of mastication, the strength of cement base required is of little clinical significance.

### Class VI Cavity Preparation for Amalgam Restoration

Class VI cavity preparation is used to restore the incisal edge of anterior teeth or the cusp tip of posterior teeth. In class VI cavities in anterior teeth amalgam is usually not filled because of poor esthetics. Such type of cavity

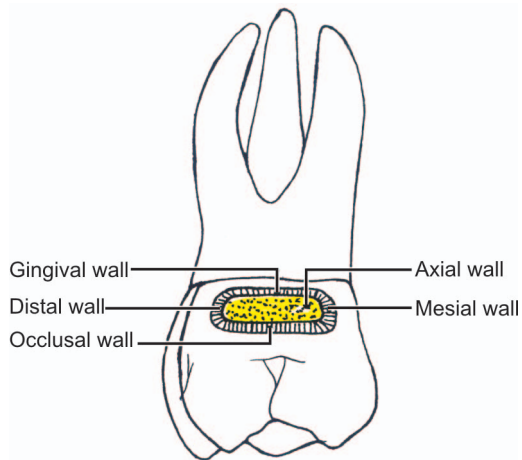
preparation is indicated where the excessive wear has removed the enamel and the underlying dentin has become carious. Such a wear pattern is more frequently seen in geriatric patients. Enamel edge becomes sharp, lacerates the tongue, lip or cheek. Rounding and smoothing such edges is an excellent service to the patient.

The class VI cavity preparation is also indicated in the hypoplastic cusp tip. Such developmental faults are more prone to caries. These defects should be restored as soon as possible. In cavity preparation, enter with the small tapered fissure bur extending to sufficient size and prepare a cavosurface margin on enamel. A depth of around 1.5 mm is sufficient to provide bulk of restoration. Retention is created by small undercuts along the internal line angles. Esthetic consideration may indicate the use of improved tooth colored

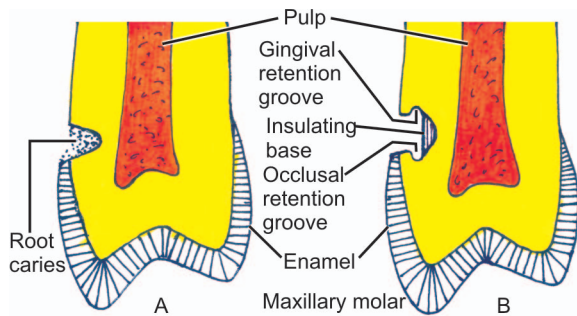


**Fig. 18.16:** Preparation of Class V cavity on maxillary molar. [A] Caries on facial surface of tooth extending around distofacial corner, [B] Round bur preparing the distal portion of preparation, [C] Distal extension prepared with round bur, [D], [E] and [F] Gingival margin trimmer completing the distal half of preparation when space for handpiece is insufficient, [G] Preparing the retention grooves by gingival margin trimmer, [H] Preparing Retention grooves in distal portion of preparation by angle former chisel, [I] Prepared cavity. D= Distal side, M= Mesial side





**Fig. 18.17:** Class V prepared cavity (Buccal view)



**Fig. 18.18:** Conventional class V cavity preparation (A) Lesion mostly on root surface. (B) After final cavity preparation remaining infected dentin excavated and occlusal and gingival retention grooves prepared. Insulating base is placed in deep cavity

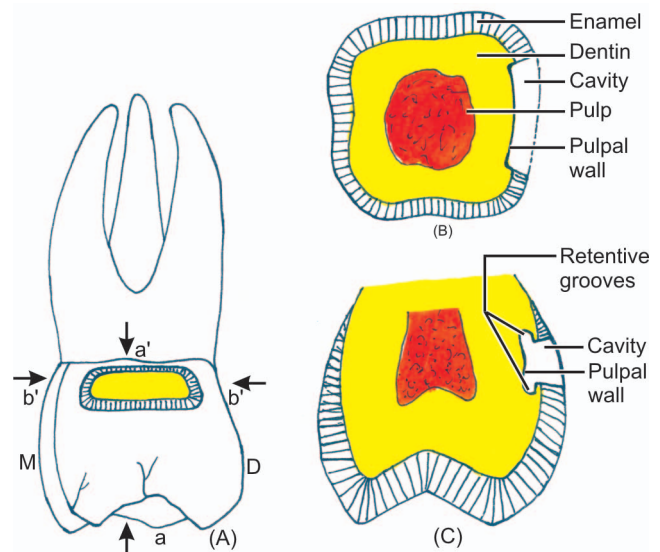
materials. In geriatric patients, excessive occlusal wear of most of the teeth form concave areas with exposed dentin, requiring multiple restorations.

## MATRICES

### Functions of Matrix

1. The primary function of the matrix is to provide missing wall, restore the anatomical contours and contact areas.
2. They support and form the necessary separation, essential for good amalgam restoration.

The quality of good matrix includes establishment of proper anatomical contour, rigidity, prevention of gingival excesses, convenient application and ease of removal.



**Fig. 18.19:** Class V prepared cavity for amalgam restoration in maxillary first molar (A) Buccal view (B) Horizontal section b-b' axial wall follow the outer contour of tooth, retentive grooves are absent in mesial and distal walls (C) Buccolingual section. In cavity a-a', curved axial wall, occlusal wall is longer than cervical wall and retentive grooves are present (.M=Mesial surface D=Distal surface.)

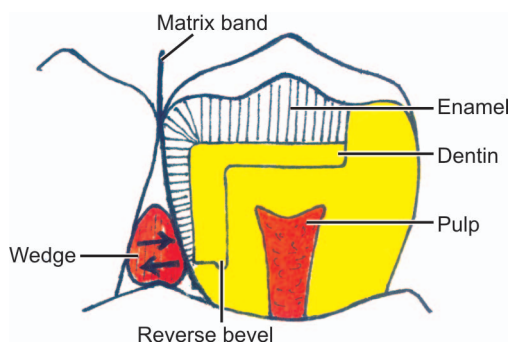
## WEDGES

A contoured matrix band in the retainer may also be deficient with respect to the formation of properly contoured amalgam restoration. The forceful condensation of amalgam may cause an excessive contour at the cervical areas, as well as overhang of restorative material in apical direction. This overhanging can be minimized by wedging the matrix band at proximal surface. Insert the pointed tip from the facial or lingual embrasure, whichever embrasure is larger, slightly gingival to the gingival margin. Wedges can be long, short, hard and soft and compressible, made from wood or plastic. A wooden wedge is trimmed to fit anatomically within triangle formed by the matrix band. The gingival wedge should be tight to prevent any possibility of overhanging of amalgam restoration. Moistening of the wedge by submerging in water permits easier placement and permits better adaptability.

When the proximal box is wide faciolingually, the double wedging is used to secure the matrix. These

## 184 Textbook of Operative Dentistry

wedges are inserted one from lingual and second from the facial embrasure. Because the facial and lingual corners are accessible to carving, proper wedging is important to prevent the gingival excess of amalgam in the middle two thirds of proximal box. The overhanging of gingival surface may occur as a result of wedge becoming loose during amalgam condensation. The operators prefer a triangular wedge to confirm the approximating tooth contour. However, round wedge is preferred with conservative proximal box because wedging action is more occlusal than using with triangular wedge. The triangular wedge is especially used in the deep gingival margins. The hardwood wedges will overcome the deficiency of space by separation of adjacent teeth. Such tooth movement utilizes the elasticity of periodontal ligament and compensates for the thickness of matrix band. After the wedge is properly inserted, assess all the aspects of band and make a correction, if needed. Once the wedge is placed examine it using the mirror again facially and lingually. Verify that the proximal aspect of the matrix band touches the adjacent tooth and proper contour has been achieved. If the band does not reach the adjacent areas after contouring and wedging, release the tension of band by a small amount by turning the larger knurled nut counter clockwise. The wedge must not restrict the band from bulging outward to develop a proper contact point. The wedge that produces too large a gingival embrasure is definitely contraindicated. The wedge must be fitted properly. There is no universal wedge. Each must be fitted for its individual intended space. Trimming of wedge can be best accomplished by a scalpel, a gold-knife or a diamond stone (Figs 18.20 to 18.22).



**Fig. 18.20:** Contoured matrix band with trimmed wedge in position in class II cavity

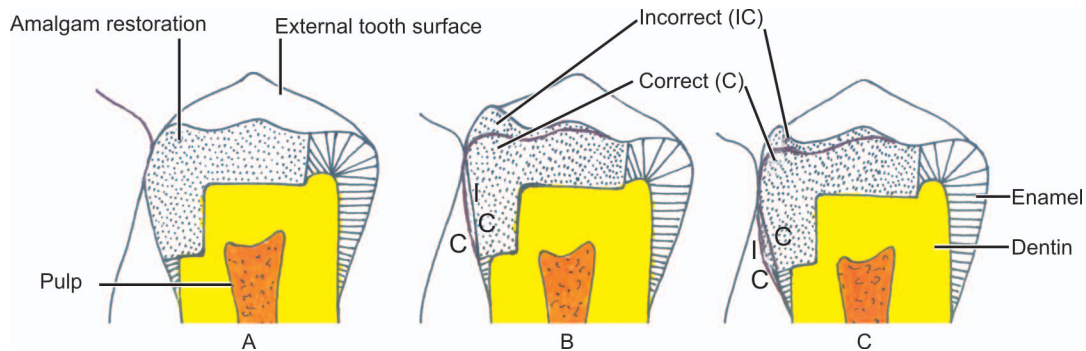
### Matrices for Buccal or Lingual-occlusal Preparations

In simple occlusal cavity preparation on posterior teeth, when caries extends into buccal and lingual surface, simple class 1 cavity becomes compound cavity in which buccal or lingual surfaces are involved. In these restorations, matrices must be used as in proximal amalgam restorations. A matrix is usually required in order to achieve the adequate condensation of amalgam, to prevent landsliding and to ensure marginal adaptation and strength of the restoration.

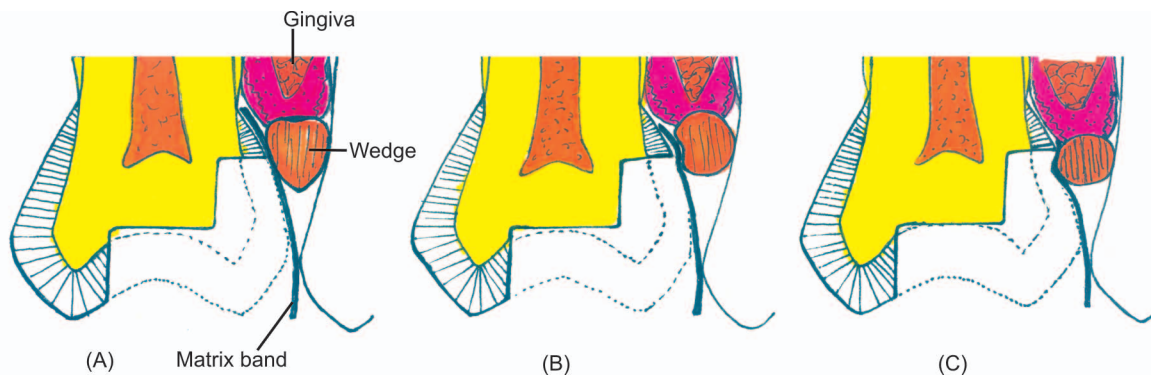
A circumferential matrix is made by adding a small segment of band material extending over the cavity within the flared band itself. The segment is held in position with higher fusing dental compound. The unique property of the lingual and facial matrix is the ability to respond to needed change in contour by pressing warmed plastic instrument against the band from the cavity side.

### Matrix Removal

After the insertion and condensation of amalgam and carving the occlusal surface, remove the retainer from the band after turning the small knurled nut counter-clockwise. The retainer is removed and band is stabilized through the indexfinger placed on the occlusal surface of the tooth. After the removal of retainer, remove any impression compound used to support the matrix. By this time restoration should have hardened enough to avoid the fracture of marginal ridge during band removal. Plier may be used to pull a band free from one contact area in the direction of wedge insertion. Separators and wedges (used for separation of teeth) which are not in contact of matrix band have been untouched so as to provide separation of teeth, while the matrix band is removed. These wedges and separators reduce the possibility of amalgam fracture as they maintain slight interdental separation. Now remove the wedge and separator and complete the carving procedures. The matrix band should never be removed occlusally. This prevents the fracture of marginal ridge. The proximal surface requires minimal carving except removing small amounts of excess amalgam at the facio and linguogingival margins and this may be refined with amalgam knives. During carving, the stroke should always be parallel to the margins (see Fig. 13.6).



**Fig. 18.21:** Proximal contour and marginal ridge height. (A). Correct proximal contour and marginal ridge height (B). Incorrect marginal ridge height with occlusal embrasure form and occlusogingival proximal contour too straight and contact too high. (C). Incorrect marginal ridge height and overcontoured occlusogingival proximal surface



**Fig. 18.22:** Position of wedge and matrix in class II cavity (A) Correct and (B) and (C) are incorrect

## PROCEDURES OF AMALGAM RESTORATIONS

### Insertion and Condensation of Amalgam

Before insertion of the amalgam, examine the outline form of the cavity preparation as ideal for amalgam restoration. Use an amalgam carrier to transfer the amalgam in the cavity. Small increments of amalgam should be extruded from the amalgam carrier, especially during initial insertion. Circular or elliptical condenser is used to condense the amalgam, and to adapt the amalgam to the prepared walls and margins, compacting the amalgam mass producing uniform and void free restorations and reducing the mercury content. Condenser with larger diameter tip requires greater condensation pressure. The direction of force should be as much as possible perpendicular to pulpal wall

and floor of preparation. For high copper amalgam little more condensation pressure is required.

During condensation, force is delivered through the face of instruments, and free mercury migrates to the surface. Condensation of a mix should be completed within the time specified by the manufacturer. An orderly effort is required by the operator to achieve minimal mercury level restoration (Fig. 18.23).

### Condensing Instruments

Condensers of various shapes and sizes are used for amalgam condensation. The faces of condenser tips are serrated. The size and shape of amalgam condenser tip is important. The force delivered to the amalgam will vary with the area of condensing tips. The selection of condenser basically depends on the outline form of cavity preparation.

The shape of the condenser tips of the condensing instrument may be triangular, round, elliptical, trapezoidal and rectangular. Shape should be selected on ease of adaptation to the walls and margins, with variations in the smooth or serrated condenser tips. The contours of regular condenser faces are usually flat, but concave and angular faces are also used in cases involving the facial surface of teeth and in occlusal, lingual or buccal grooves. The contoured condenser faces are usually used as a supplement and in conjunction with regular condensing instruments (Figs 18.24 and 18.25).

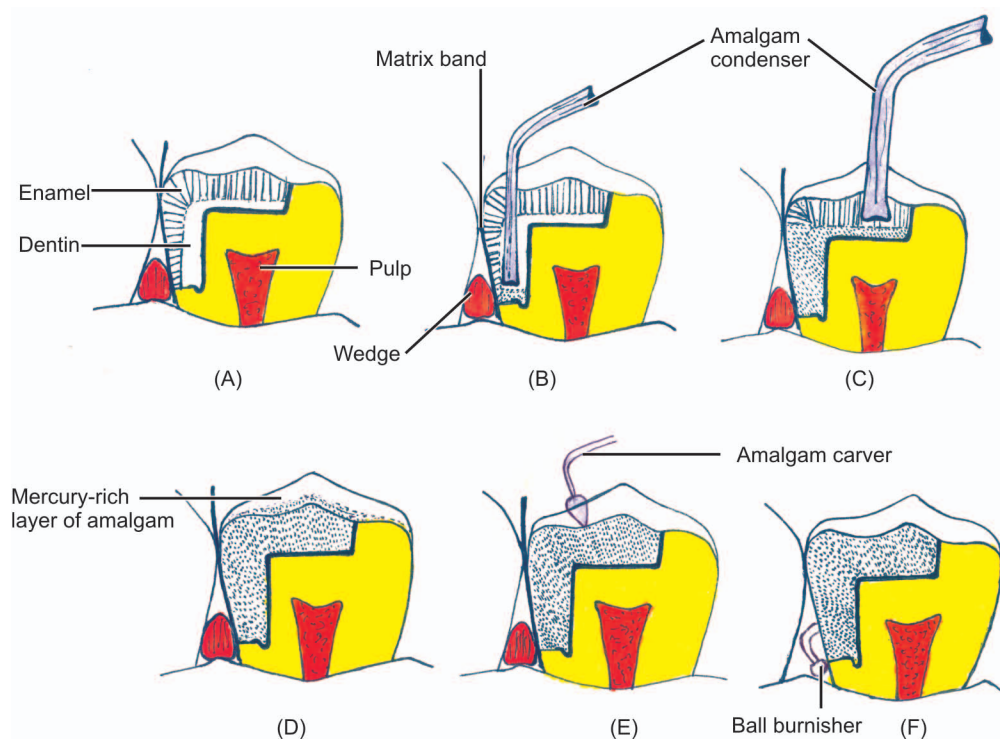
### Mechanical Condensation

The mechanical condensers are grouped into the “vibratory” and the “impact” types. Mechanical

condenser may be thought advantageous under certain situations to gain the objective of condensation especially in the hands of some clinicians.

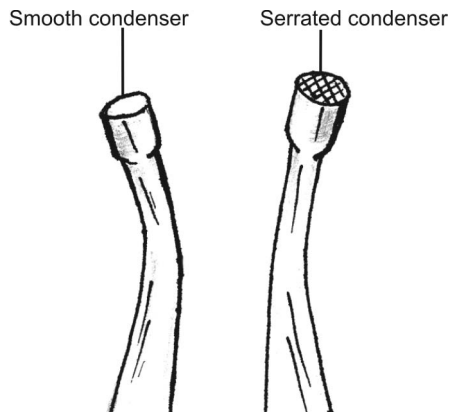
### PRECARVE BURNISHING TO ADJUNCT THE CONDENSATION

Precarve burnishing is a form of condensation. It is the process of rubbing, usually performed to make the surface shiny. Overfilling of amalgam is done and marginal amalgam is well condensed before carving. Overpacked amalgam is burnished immediately with heavy strokes with adaptation and compaction of the amalgam mass at the margins and surface of the restoration. Burnishing slightly alters the contour of the surface.

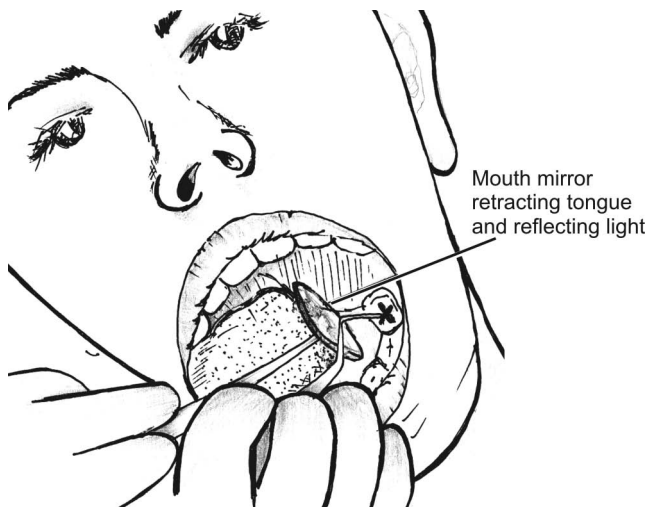


**Fig. 18.23:** Steps of amalgam condensation in class II cavity (A) Cavity with contoured matrix band and wedge (B) Placement of amalgam in increments initially into cervical area with condensation to gain adaptation and derive excess mercury to the surface (C) In wider area condenser having larger diameter is used (D) Condensation brings mercury-rich layer of amalgam on the surface which is removed from final restoration (E) Occlusal carving and burnishing is completed (F) Proximal carving and burnishing is done after removing wedge and matrix band





**Fig. 18.24:** Smooth vs. serrated condensers. Serrated condensers “bite” into the material resulting in better condensation, whereas smooth-faced condensers skid over the surface



**Fig. 18.25:** Amalgam condensation

## CARVING OF RESTORATIONS

The carving involves the cutting of overpacked alloy forming the contour. It begins immediately after the condensation has been completed. The carving instruments have discoid and cleoid blade design. Larger instrument is used first, followed by smaller instruments. In Class II restoration, marginal ridge of proximal surface is established with the Ward's “C” carver while the matrix band is in position. During the carving, movement of instrument should be parallel to the margin and edge of blade should be perpendicular to the margins, to avoid ditching of the metal and to

minimize the overlay. In proximal cavity preparation, carving of the cervical margins should begin following the removal of matrix band. During cavity preparation and restoration, contouring and wedging of matrix band will minimize the cervical overhang and extension. However, carving of this area is necessary.

On occlusal surface outline form, anatomy, diagnostic cast, functional contacts and remaining tooth anatomy, all serve to guide in development of the occlusal surface. Care should be taken that amalgam is not carved out of occlusion. After carving, outline of restoration margin reflects the contour and location of prepared cavosurface margins, which show a regular outline form. If restoration outline is larger, irregular with undercurved areas it requires further and careful carving (Fig. 18.26).

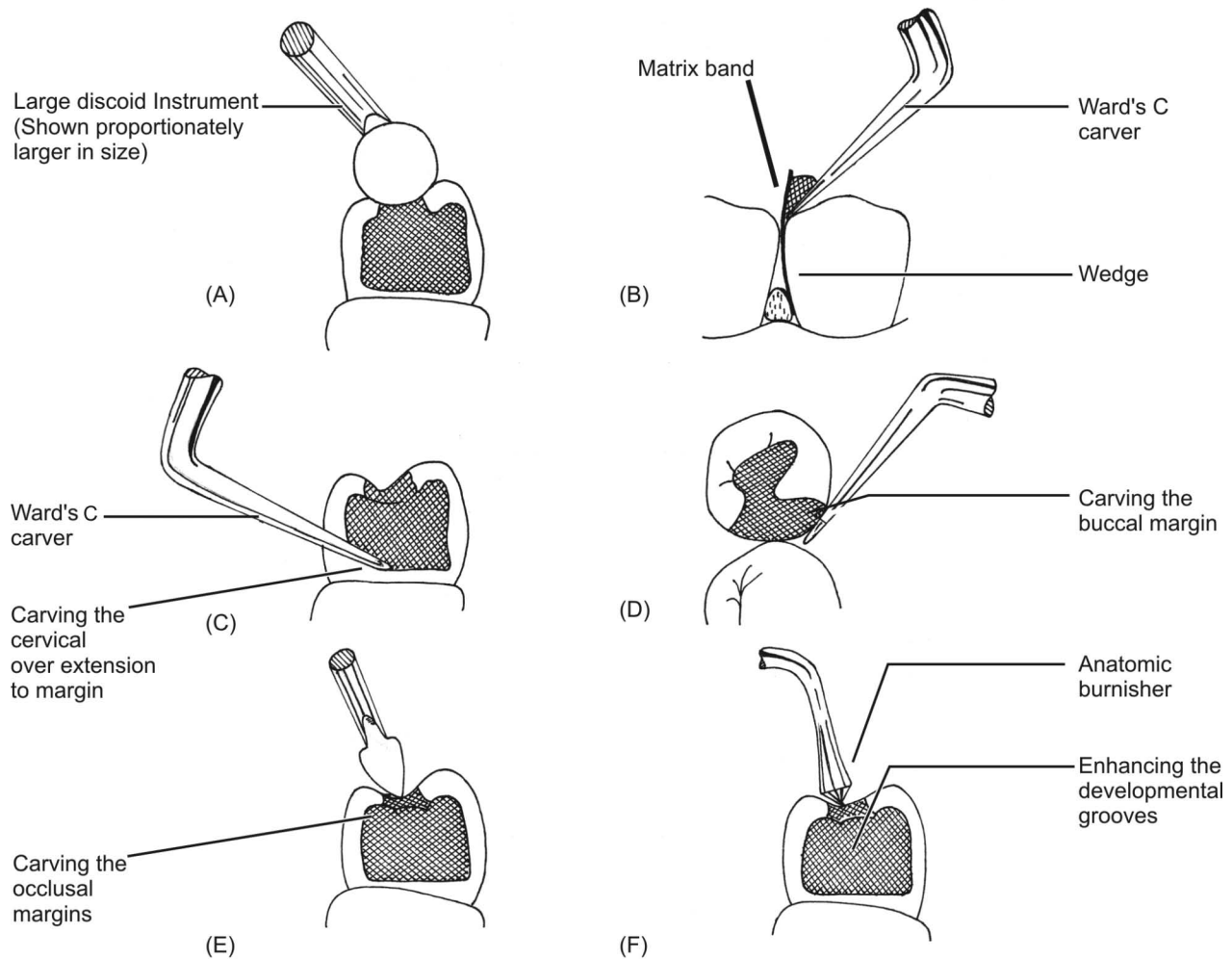
## POSTCARVE BURNISHING

It is rubbing with light pressure of the carved surface with suitable size of burnisher to improve the smoothness with shiny appearance. In low copper amalgam, restoration and its burnishing produces denser amalgam at the margins. In high copper amalgam restoration postcarve burnishing has no significant effect on the clinical performance (Fig. 18.27).

## OCCCLUSION OF RESTORATION

After the completion of carving, burnishing and after removal of rubber dam, the patient is made to bite on very thin layer of wet cotton with light pressure to avoid the fracture of the restoration since it is weak at this stage. If the restoration is high, it indicates the premature contacts which are carefully removed. Then carving is carefully done. Visually inspect the contact potential of restoration to assess the correct closure in occlusion. To ensure the occlusion is correct, place a piece of articulating paper on the restoration and ask the patient to close the teeth with light pressure. High spots will be marked, which are removed by removing superficial layer of amalgam by sharp instruments with additional carving. The process of light closure is repeated and carving is finally accomplished until the teeth are in their pre-restoration occlusion.



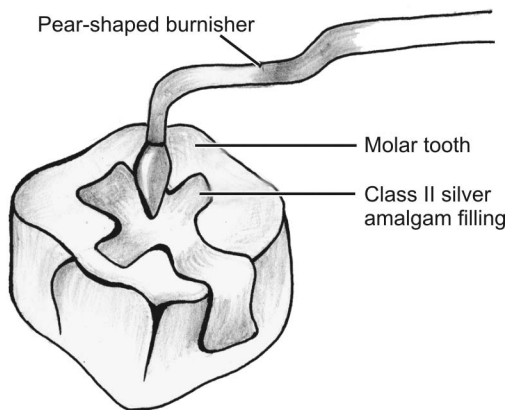


**Fig. 18.26:** Carving sequence for amalgam restoration. [A] Removal of bulk excess with a large discoid instrument, [B] Establishing outer incline of marginal ridge with ward's C carver while matrix band is still in position, [C] Carving the cervical over-extension to margin with ward's C carver using adjacent tooth contour as an instrument guide, [D] Carving the buccal margin of an extended proximal box, maintaining anatomic line angle, [E] Carving the occlusal margins so that no over-extension remains, [F] Enhancing developmental grooves with anatomic burnisher following carving. (All instruments are shown proportionately larger in size than the tooth to make their shape and placement clear)

On occlusion, if there are high points carve away the excess amalgam to remove the undesirable contact areas. Finally, burnish the surface and caution the patient not to bite any hard thing for few hours. (These hours vary according to the recommendation of the manufacturer of the amalgam alloy).

## FINISHING AND POLISHING

Finishing and polishing procedures are necessary to complete the carving, to refine the anatomy, contours and marginal integrity and to enhance the surface finish of restoration. Finishing and polishing are not done within 24 hours of insertion, since the crystallization of



**Fig. 18.27:** Postcarve burnishing of amalgam restoration

amalgam is not complete. During the carving, margins are located and desired contours and occlusion are developed. Finishing and polishing reduces the surface roughness of the restoration. A smooth and homogenous surface is less prone to tarnish and corrosion hence a homogenous surface is achieved.

In high copper amalgam restoration, high polishing is not necessary, due to its less susceptibility to tarnish and corrosion. These procedures must not leave the under-contoured restoration. After polishing, tip of explorer should pass from restoration to tooth surface without catching. If the occlusion is not restored or perfect continuity of surface is not obtained, a fine pointed, fused alumina stone is used to correct the surface contours. The stone is placed on surface so that its long axis is at right angle to the restoration. After this, it is re-examined with explorer. If roughness is not detected, light touch with finishing bur is used on restoration surface to finish the restoration completely. Finishing of proximal restoration begins carefully with cervical margins. Discrepancies existing in the gingival area should be removed by using Rhein trimmers. A flame-shaped bur should be used in accessible margins to prevent unnecessary removal of restoration. If smooth surface is achieved, polishing procedure is initiated.

For polishing, rubber abrasive point is used at low speed to produce smooth surface. After few seconds of polishing if the amalgam surface does not exhibit smoothness and if the surface is rough, finishing is done again with finishing bur as necessary. Polishing is done at slow speed with rubber point to prevent the danger of point (margins) disintegration and elevation of the temperature of restoration and tooth. An

excessive rise in temperature can damage the pulp and surface amalgam will show cloudy appearance, indicating the mercury brought to surface. Margins should not exhibit any ditching. Round finishing burs are recommended to correct poorly defined anatomy.

## AMALGAM RESTORATION REPAIRING

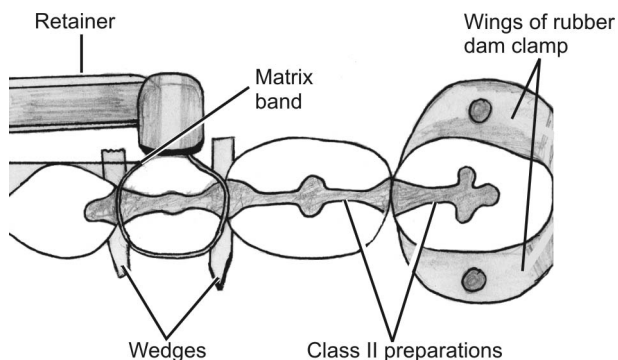
Amalgam filling repair is successful only when a small area of a single surface filling is to be repaired. When the recurrent caries occurs alongside the margins of the large restoration, it is better to remove the old restoration with removal of recurrent caries. Repair of large old filling with patch work does not last long. The fractured amalgam filling is not repaired successfully, if caries involves a marginal ridge. The entire restoration is removed and fresh amalgam is condensed. The secondary caries is the principal cause for restoration requiring replacement while poor margins and tooth fracture are next in order. Factors under control of the dentist and the patient may prevent the failure by sound cavity preparation, adaptation of amalgam to the walls and margins, re-establishing the contours, finishing the surface and margins. For repair the amalgam of same make and composition should be used to reduce corrosion. Certain advantages with amalgam are that less chair side time is required, corrosion provides a built-in resistance to microleakage. In those teeth in which esthetics is not a prime consideration, amalgam is the choice of restorative material.

## QUADRANT DENTISTRY

If several teeth situated in different quadrants of dentition are to be restored, usually it is convenient to treat the teeth by the quadrantwise. In this all the restoration in one quadrant are completed in one sitting. For maximum work output each rotary or hand instrument is used on all the teeth of a quadrant where it is required before being replaced by another instrument.

Quadrant dentistry is more efficient and requires less chair time for patients. The use of rubber dam is planned in quadrants where the preparation is indicated. In Class II preparation, matrix bands are used in individual restoration on alternate preparation and at a time maximum two teeth are restored. Extensive cavity needs a single tooth restoration. Proximal box size alters in different teeth. A smaller proximal box

size is ideal because proximal box carving is inaccessible when larger size cavity is restored first and there is a risk for damaging the gingival contour of restoration. A finishing strip can be used to refine the contour of proximal restoration, but finishing strip is indicated in open proximal surface (Fig. 18.28).



**Fig. 18.28:** Quadrant dentistry in which in a quadrant all class II preparations with similar sized proximal boxes are restored with banding of alternate preparations simultaneously, starting with a most posterior preparation

## MERCURY HYGIENE

Mercury hygiene is an important consideration for safe dental amalgam management. Biological properties of dental materials vary with toxicity and sensitivity reactions. Most of the dental materials interface locally and local reaction may vary. The clinical factors, for example, exposure time and concentration of materials determine the toxicity. Always store mercury and amalgam scrap in tightly covered bottles under lock and away from children.

The potential hazards of mercury must be known. Very rarely, scanty mild to moderate local type of allergic reactions may be observed. Following precautions must be observed

1. Dental personnel should help to minimize the contamination with mercury.
2. There should be proper ventilation in the workplace.
3. Mercury is toxic also by inhalation. The mercury vapors should be monitored in office periodically.
4. Use of mercury should be done with care, and as far as possible avoid the skin contact.
5. Its toxicity has cumulative effects.
6. Handling of mercury and mixing of amalgam should be done on a separate large tray with

raised edges on all sides (away from a source of heat). This will prevent any spilled mercury spreading and will facilitate its recovery. The surgery floor should be smooth, without carpets, cracks and the surgery well ventilated.

7. Small droplets of spilled mercury can be collected with the aid of a 'mercury-collecting forceps' or a small amount of freshly mixed amalgam, that will easily absorb liquid mercury.
8. Ideally a high-energy mixer should be equipped with a protective cap to cover the capsule while mixing.
9. Removal of amalgam fillings must be done under water cooling and with effective suction. The use of eye protection and mouth mask is advisable.
10. Excess mixed amalgam should be kept in a special 'Mercontainer' or at least in a closed container filled with photographic fixer.

## AMALGAM BONDING SYSTEM

The important disadvantage of the amalgam is that it does not adhere to the walls of the cavity. To overcome this disadvantage, bonding systems to bond the amalgam to dentin and enamel have been developed. The systems are used to seal the cavity tooth structure and bond to enamel and dentin.

Amalgam is hydrophobic while enamel and dentin are hydrophilic, hence bonding systems must have dual properties to achieve optimal wetting. Hence, the bonding system is such modified with a wetting agent, (comonomer) having the property of wetting both hydrophilic and hydrophobic surfaces. The monomer molecule having hydrophilic and hydrophobic ends of 4-methoxy ethyl trimellitic anhydride (4 META) based systems are used. Bonded amalgam restorations adhere to the tooth structure through a resin mediated attachment.

Debonding takes place by fracture along with interface. In absence of chemical bonding at the interface micromechanical bonding takes place. To achieve this the thick layers of bonding agents (10 to 50 micron) are applied. For this bonding material is applied about 8 to 10 times or the thickening agents are added to the bonding material.

Advantages of bonding agents are as follows:

1. Dentin sealing
2. Resistance form is very much improved
3. Retention form is increased
4. Cavity can be made very conservatively, and extensive undercut is not required
5. Improves marginal seal
6. Use of retention pins is eliminated
7. Microleakage, recurrent caries and postoperative sensitivity are reduced as bond at tooth restoration interface is provided.
8. Incidence of marginal fracture is reduced
9. Biological sealing of the pulpodentinal complex is provided.
10. It is a cost effective treatment for extensively carious tooth
11. Single appointment restoration of extensively carious multiple teeth is possible.

### Indications of Bonding

1. When remaining tooth structure after cavity preparation is weak, bonding reinforces resistance form of the restored tooth where sufficient thickness of the amalgam cannot be provided.
2. Bonding provides auxiliary retention in deep bite cases where cervico-occlusal dimension is less than normal.
3. In extensively carious posterior teeth as cheaper substitute for cast metal and metal ceramic restorations.
4. As core for cast crown restoration.

### Limitations of Amalgam Bonding

1. It is technique sensitive system, amalgam must be condensed over wet adhesive resin.
2. After few years of use bond strength is reduced due to repeated thermocycling (hot and cold food) in the oral cavity.
3. Cost of bonded amalgam restoration is more than non-bonded amalgam restoration.

## TECHNIQUE OF BONDED AMALGAM

### 1. Cavity Preparation

- A. In conservative cavity preparation conventional retention and resistance forms are not strictly followed.

- B. Healthy tooth structure is preserved as much as possible as bonded amalgam strengthens the remaining weak tooth structure.

- C. To isolate the tooth rubber dam is applied.

### 2. Bonding Agents and their Mode of Action

Bonding agents commonly used are as follows:

#### Meta System

To remove smear layer and demineralize the dentin surface a solution of 10 percent phosphoric acid or citric acid and 3 percent ferric chloride is used. Now a primer is applied on the conditioned dentin. Then a self-curing 4 – META system is applied. Now high performance additive powder (HPA) in amalgam bond plus containing polymethacrylate fibers are used. This crosses the interface between the amalgam and the bonding resin. In this way it produces a reinforced union between the two materials (Fig. 18.29).

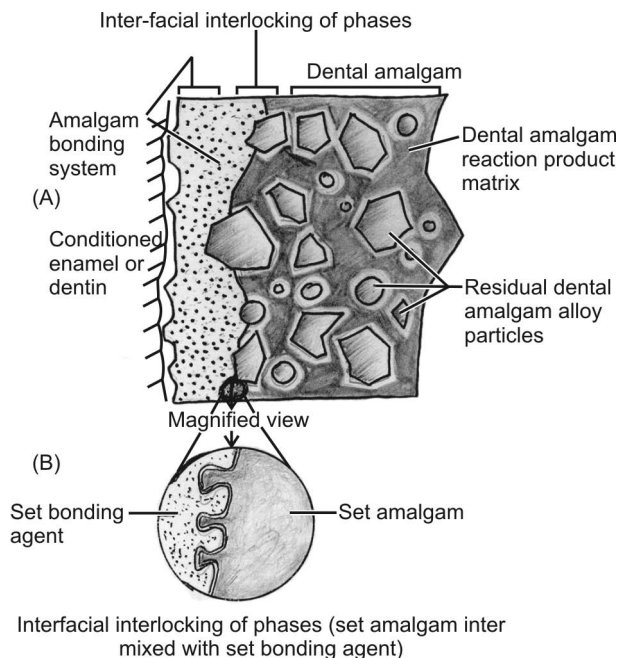
#### Procedure

1. The tooth is isolated with rubber dam and made caries free and conservative cavity is prepared but all unsupported enamel rods are removed.
2. In deep cavities pulp is suitably protected.
3. Automatrix and wedges are placed. Automatrix is preferred as its placement is easy and it does not hinder manipulation.
4. Enamel and dentin walls of the cavity are etched with 10% citric or phosphoric acid gel for 15 seconds. Thereafter acid gel is removed. The cavity is washed and dried. Dull white frosted appearance shows proper etching.
5. On all the cavity walls suitable adhesive primer (primer A+ primer B, all bond 2 system) is applied.
6. With a disposable brush an enamel dentin bonding agent (all bond liner F) is evenly applied.
7. Before the bonding agent is dried, freshly triturated high copper amalgam is condensed into the cavity. The amalgam is carved, finished and polished as usual.

## BONDING INTERFACE

The bonding interface consists of tooth, amalgam and in between them the intervening adhesive resin (Fig. 18.29).





**Fig. 18.29:** Adhesive joint created with amalgam bonding agent. Micro-mechanical bonding holds bonding agent to the surface conditioned enamel and dentin. (A) Alloy particles present in amalgam and irregularities in amalgam provide retention to bonding agent where thick adhesive film allows micro-mechanical interlocking (B) Magnified view of encircled portion of A, showing thick adhesive film allow micromechanical interlocking

The bonding interface may consist of the following.

- A. Tag formation
- B. Precipitates on pretreated dentin surfaces to which adhesive resin mechanically or chemically binds.
- C. Formation of hybrid layer of reinforced dentin.
- D. Chemical binding to the inorganic and/or organic components of dentin and/or enamel.

### SCOPE AND PROGNOSIS OF BONDED AMALGAM RESTORATION

Bonded amalgam filling is the combination of conservative cavity preparation, good properties of amalgam, better retention and resistance with good marginal seal. As with other filling materials the selection of the materials and manipulation affect their properties. Dietary and oral hygiene habits alter the prognosis of bonded amalgam restorations.

There are very few controlled comparative studies on these bonded amalgam fillings, hence definite conclusion cannot be arrived at about their prognosis and future use. However, most of the workers have good hope about their future and expect that very soon bonded amalgam fillings may be routinely used in place of conventional unbonded amalgam fillings.

### REASONS FOR FAILURES OF AMALGAM RESTORATIONS AND THEIR REMEDIES

All over the world amalgam has been the most widely used restorative material in posterior teeth since 1860. Since 1970 because of the presence of mercury in it and development of newer restorative materials its use has been restricted and banned in few of the advanced countries. Still, on over all basis the world over, this is the maximum used restorative material for posterior teeth.

The life of a properly selected and restored silver amalgam restoration is about 10 years. In the beginning for few years the restorations appear excellent. As the time passes gradually some changes start taking place which alter the properties of the restoration. These changes may result in tarnish, corrosion, recurrent marginal caries, discoloration of teeth, fracture of restoration or tooth and ultimately loss of restoration.

Most common causes of failure of dental amalgam can be classified as follows.

- I. Pain after amalgam restoration
  1. *Pulpal involvement*: When filling is very close to the pulp without any proper lining or base pulp may be involved.
  2. *Periodontal involvement*: When class II filling is overhanging over the periodontium causing inflammation of the gingiva showing periodontal involvement.
- II. Macroscopic causes.
  1. Marginal fracture of amalgam—takes place due to defective cavity preparation, inadequate condensation and poor edge strength of the amalgam.
  2. Secondary or recurrent caries—takes place due to marginal leakage. Changes in temperature of oral cavity are one of the important causes of marginal leakage (Figs 18.30 and 18.32).



3. Bulk fracture of restoration—takes place due to defective cavity preparation.
4. Tooth fracture—takes place due to defective cavity preparation.
5. Dimensional changes—take place in zinc alloys due to moisture contamination
6. Discoloration, tarnish and corrosion—take place due to improper manipulation and finishing and polishing of filling.
7. Discoloration of tooth—takes place due to percolation of silver salts in the dentinal tubules (Figs 18.31 and 18.32).

### III. Microscopic causes

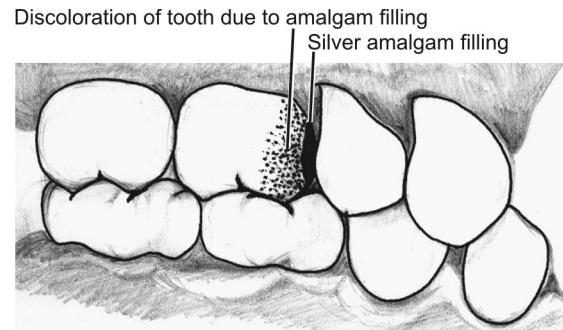
1. Internal stresses due to excessive masticatory forces may fracture filling or the tooth.
2. Pain after amalgam restoration.

Another method for describing reasons of failure of amalgam restorations are on the basis of procedural defects on the part of operator.

## PROCEDURAL REASONS FOR FAILURE OF AMALGAM RESTORATIONS

The reasons for failure of amalgam restorations can be divided under following four headings.

- I. Defective cavity preparation
- II. Defective manipulation
- III. Defective matrix adaptation
- IV. Defective materials



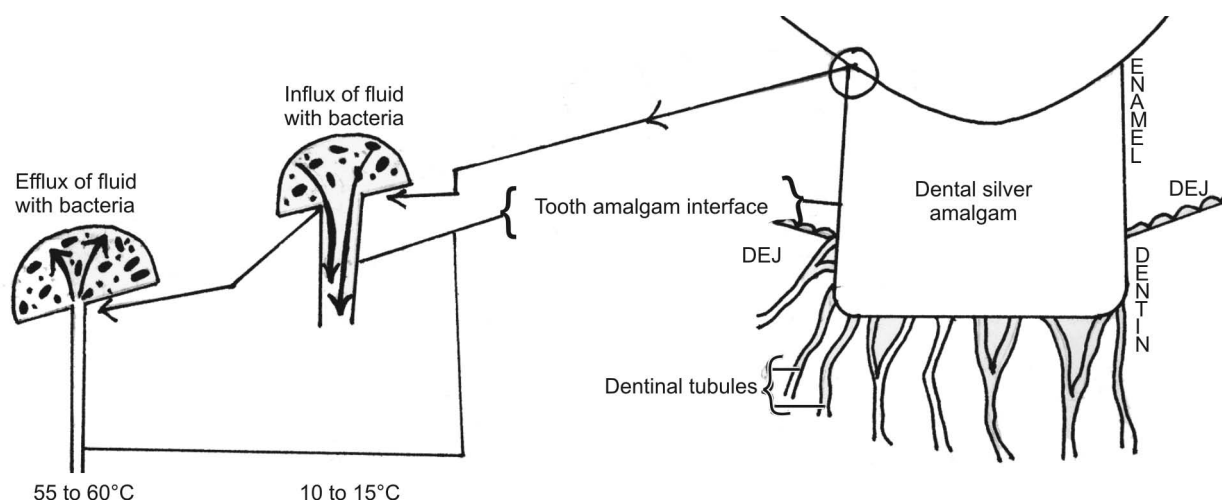
**Fig. 18.31:** Discoloration of tooth due to percolation of silver salts in dentinal tubules of old amalgam filling

### I. Defective Cavity Preparation

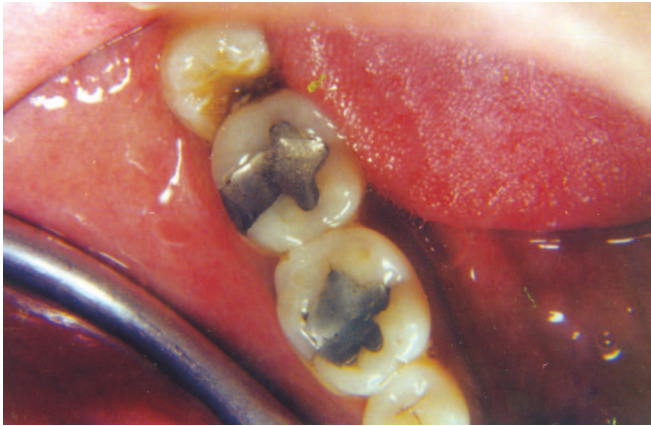
This is the main cause of failure of amalgam restorations. Healey and Phillips (1949) assessed the causes of 1521 defective amalgam restorations. They observed that 56 percent of the failures were due to defective cavity preparation and 42 percent of the failures were due to defective manipulation of amalgam and rest only 2 percent were due to other causes.

The following defects usually occur during cavity preparation

1. *Insufficient occlusal extension:* Insufficient extension for prevention so as not to include



**Fig.18.30:** Marginal leakage due to changes in oral cavity temperature. Percolation along the margins of an amalgam restoration due to its difference in linear coefficient of thermal expansion from tooth structure during intraoral temperature changes. Fluid influx occurs during cooling (10 to 15°C-contraction of amalgam). Fluid efflux occurs during heating (55 to 60°C-expansion of amalgam) (DEJ= Dentinoenamel junction) of amalgam



**Fig. 18.32:** Recurrent caries around faulty amalgam restoration in first and second mandibular molars

adjacent deep pits and fissures increases chances for recurrent caries. This more commonly occurs in persons with high caries index. All susceptible pits and fissures should be included in the cavity margins.

2. *Under extension of the proximal box:* The walls of the proximal box of class II cavity must be extended to self cleansing areas to prevent recurrent caries. If the proximal margins of the filling are not sufficiently extended into the embrasures they will not be cleaned by brushing and during mastication giving rise to recurrent or secondary caries. Over extension into the embrasure areas specially in lower premolars and on distal sides of maxillary and mandibular first molars makes the cavity walls weak. Hence, over extension of the margins of the cavity into the embrasures must be avoided.
3. *Over extended cavity preparation:* Unless required for caries removal ideally the buccolingual width of the cavity at isthmus of class II cavity for amalgam should be less than one-fourth of the intercusp distance. If the buccolingual width of the cavity is more than half of the intercusp distance, capping of the cusps should be done. The capping of the cusps must be done if the cavity preparation is extended to two-third of the intercusp distance, otherwise there are chances of fracture of the cusp. For cusp capping onlay cast restoration is ideal. If amalgam is to be used for cusp restoration then it must be atleast 2 mm thick over the cusps, otherwise the amalgam will fracture over the cusps under masticatory load.
4. *Cavity depth:* For amalgam the minimum cavity depth should be 2 mm so that the bulk of the amalgam can prevent its fracture under masticatory load. For functional cusp capping minimum thickness is also 2 mm. For non-functional cusp capping it should be at least 1.5 mm thick and in deep pits and fissures it should be at least 1 mm.
5. Pulpal floor of the cavity must be flat to avoid fracture of amalgam and the tooth. Curved or sloppy floor acts as a wedge. Around deep excavation sites of caries, flat floor should be provided as much as possible.
6. The tooth and amalgam junction should be a butt joint specially where the masticatory forces fall. In acute cavosurface angles enamel margins fracture under load. In obtuse cavosurface angles marginal amalgam fractures under load. Unsupported enamel rods must be removed as they are likely to give rise to secondary caries.
7. In class II cavities sometimes there is fracture of amalgam at the isthmus due to inadequate width and depth or inadequate proximal retention form.
8. The sharp axiopulpal line angle may lead to fracture of amalgam due to concentration of stresses in that area. The rounding off of the axiopulpal line angle is a must to provide bulk of the amalgam with sufficient strength.
9. Wherever additional retentive forms and devices are used to provide additional retention they must be confined in dentin and not extend in enamel. Amalgam must be at least 2 mm above the retention screws or pins otherwise the pin will act as a wedge to fracture the amalgam.
10. Incomplete removal of the carious dental tissues before restoration may result in fracture of the restoration under masticatory load.
11. Hyperemia of the pulp giving rise to pain and sensitivity may develop in absence of the following during cutting.
  - i. Effective cooling

- ii. Sharp burs
- iii. Intermittent cutting.

## DEFECTIVE AMALGAM MANIPULATION

Defective amalgam manipulation may occur in the following forms.

### Improper Condensation

The purpose of condensation is to reduce residual mercury content in the amalgam. The ideal mercury content is below 55 percent, which should be obtained during condensation. During condensation the following are important.

- a. Even and proper spread of amalgam in all corners of the cavity. Small increments to ensure proper condensation should be used. Adequate condensation pressure should be used.
- b. Delayed use of triturated amalgam should be avoided – Amalgam must be used within 4 minutes of its trituration. For larger cavity multiple mixes and triturations should be used one after another.

### Incorrect Mercury Alloy Ratio

The mercury content in the amalgam should be below 55 percent. If the mercury content is more than 55 percent, the strength of the amalgam will be reduced. If too high mercury content is used in trituration, the excess removal is difficult by squeezing and condensation. Hence, before trituration proper proportion of alloy and mercury should be used. Mulling of the amalgam which can be done manually or mechanically is the continuation of the trituration. It is done so that all alloy particles are properly coated with mercury. Mulling should not be done by bare hands as moisture will be incorporated into the amalgam and adversely affect its properties. Mechanical mulling is done in the amalgamator by triturating it for one to two seconds after removing pestle from the capsule. The capsule must be cleaned before each use. Under-trituration leads to soft powdery scattered mix while over-trituration may produce weak amalgam and it may break the already formed amalgam matrix.

### Contamination During Manipulation

During various steps of manipulation if the amalgam is mixed with even slight moisture the resulting amalgam will be weak. The weakness is more pronounced if the

amalgam alloy contains zinc. Moisture in zinc containing amalgam causes delayed expansion, which causes pain, weakness at the margins, tarnish, corrosion, pitting and blistering.

### Defective Finishing and Polishing

Polishing with heavy pressure causes spur-like overhangs, which fracture under mastication causing leaky margins wearing of the amalgam and caries susceptible areas. It also generates excessive heat which may irritate the pulp. Therefore, polishing should be done with very light pressure.

Carving of deep pits and fissures will reduce thickness of amalgam resulting in fracture, hence must be avoided. Tarnished, corroded, pitted and rough surface predisposes to failure, plaque accumulation and gingival irritation. During polishing the temperature at the surface should remain below 65 degree centigrade, otherwise mercury will come on the surface causing weakening of surface.

## POST RESTORATIVE PAIN

The causes of post restorative pain are as follows.

- A. High points in amalgam filling result in periodontitis or, fracture of the filling or tooth and pain.
- B. Delayed expansion in zinc containing alloys causes high and rough filling resulting in high points and fracture of filling or tooth and pain.
- C. Inadequate pulp protection may give rise to pain as amalgam is good conductor of temperature. Excessive changes in temperature in oral cavity will give rise to pulpal hyperemia leading to pain. Below all amalgam restorations varnish lining must be given and amalgam must be condensed after drying out of the varnish.
- D. Continuous leakage around filling may cause postoperative pain and 'Amalgam Blues' which are bluish discolorations of the margins of the cavity.
- E. When patient immediately bites after filling before amalgam sets, it may fracture leading to pain, hence postoperative instructions must be clearly explained.

## DEFECTIVE MATRIX ADAPTATION

There are various types of matrices available. Proper matrix and retainer should be selected to provide the missing wall. It should be properly shaped according to the morphology of the tooth, contact areas and the

marginal ridges. Properly shaped wedge should be used so that the matrix is properly adapted to the surface of the tooth and provides missing walls and contours. The matrix should be properly made stable before condensation of amalgam. The stability of the matrix is a must to avoid distorted restorations, gross marginal excess, overhanging fillings and uncondensed soft amalgam. Overhanging class II fillings will gradually destroy periodontium. Therefore for all two or more surface fillings proper matrices must be applied before condensation of the amalgam.

## DEFECTIVE MATERIALS

When dental silver was introduced there was no standardization of the silver amalgam and the mercury, which resulted into failure of the restorations. The properties of the amalgam were not balanced and controlled, resulting in the failure of the restorations. Now-a-days with proper and well tested specifications by American Dental Association and various other association and National Bureau of standards the chances of inferior or defective materials have been very much reduced. Therefore, now-a-days the failure of the restoration is due to other factors than the defective materials. However, the materials of standard and well reputed manufacturer should be used.

## GALLIUM IN PLACE OF MERCURY IN AMALGAM

Due to possible harmful effects of mercury in the silver amalgam, its use has been banned and restricted in some advanced countries. To overcome the chances of harmful effects of mercury, gallium metal which has second lowest melting point (next to mercury), 28.75°C, has attracted the attention. Its boiling point is 1983°C. The density of gallium is 5.91 gm at 20°C. It can wet tooth structure (Table 18.1).

### Properties of Silver Gallium Alloy

1. With same instruments used for silver amalgam, gallium amalgam can be manipulated and condensed.
2. Its strength is almost equal to silver mercury amalgam.

3. Like silver mercury amalgam the strength of gallium amalgam also increases with time.
4. Gallium amalgam alloys provide better marginal seal than silver amalgam as they uniformly expand after trituration for about one hour.
5. It sets faster than silver mercury amalgam hence can be finished and polished after one hour.
6. Most of the physical and mechanical properties of gallium alloys are similar to high copper mercury amalgam, except the corrosion resistance of gallium is much inferior.
7. Gallium alloys stick to the instruments, hence its handling is untidy.

**Table 18.1:** Comparison of the physical properties of silver gallium amalgam with high copper silver mercury amalgam

| Property                                               | High copper silver alloy gallium amalgam | High copper silver alloy mercury amalgam |
|--------------------------------------------------------|------------------------------------------|------------------------------------------|
| 1. Compressive strength (After 6 hours)                | 350 MPa                                  | 370 MPa                                  |
| 2. Percentage of setting contraction (-) expansion (+) | +0.39                                    | -0.05                                    |
| 3. Creep percentage                                    | 0.09 ± 0.03                              | 1.04 ± 0.06                              |

### Composition 1. Amalgam Alloy for Gallium

|                   | Percentage |
|-------------------|------------|
| A. Silver         | - 55 to 65 |
| B. Tin (Sn)       | - 20 to 30 |
| C. Copper (Cu)    | - 10 to 16 |
| D. Palladium (Pd) | - 10 to 15 |
| 2. Liquid         | Percentage |
| A. Gallium (Ga)   | - 57 to 67 |
| B. Indium (In)    | - 15 to 25 |
| C. Tin (Sn)       | - 15 to 25 |

**Reaction:** The amalgam alloy and the liquid gallium are tritured as usual. The reaction between powder AgSn particles and liquid gallium results into the formation of AgGa phase and a pure tin phase



The mixed powder and liquid tends to adhere to the walls of the capsule and the instruments, hence is



untidly to handle. This problem of adhering can be reduced by adding a drop of absolute alcohol to the mix before trituration. Alcohol gradually evaporates and does not adversely affect the properties of the amalgam.

### Clinical Considerations

1. *Setting expansion*: In initial stages controlled expansion is good but uncontrolled expansion is deleterious to the success of the restoration. In larger restoration expansion is so much that it may even (a) fracture weakened cusps, and (b) cause post-operative sensitivity.
2. *Creep value*: In gallium alloys creep value is less which is favorable for the restoration.
3. *Compressive strength*: It is adequate for small restoration.
4. *Time consuming*: The amalgam being sticky, takes more time for condensation and matrix band has to be removed very carefully otherwise the filling may break. Cleansing of the instruments is also time consuming.
5. Gallium amalgam has very high wetting ability, hence the final restoration is highly resistant to microleakage.
6. *Costly*: Gallium amalgam is about 16 times costlier than the silver mercury amalgam.

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## 198 *Textbook of Operative Dentistry*

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# 19

## Pin Retained Restorations

Most of the teeth, except restored with cast restorations, are usually restored by making small undercuts in the dentin. When the cavity size is enlarged due to caries or a large crown portion is lost due to some reason, the remaining tooth structure is decreased and it becomes difficult to obtain resistance and retention form. In such cases dentin lock and dentin slots are prepared in the dentin (Figs 8.58 (A) and 19.1).

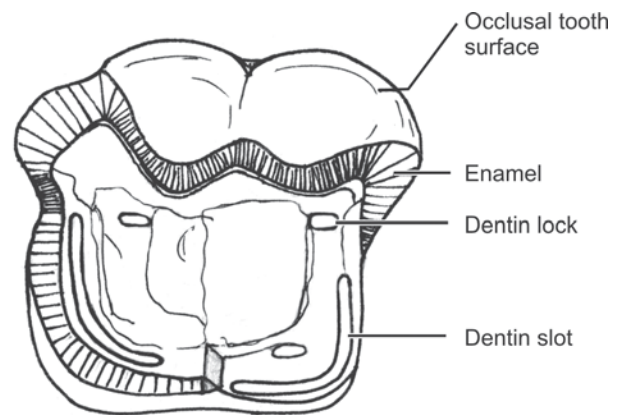
### RETENTIVE PINS

When amalgam restoration is stretched beyond its elastic limit it will fracture. Similarly, fracture at amalgam isthmus in class II filling occurs due to wide and shallow proximal box. In 1958 Dr Miles Markley introduced stainless steel pins to provide retention and resistance form. Pins retain the restoration in the prepared tooth structure together and secondly, reinforce the tooth by cross-splinting of weakened cusps. Three types of pins are used; they are (A) Self-threading (B) Cemented and (C) Friction locked (Fig. 19.2) (Table 19.1).

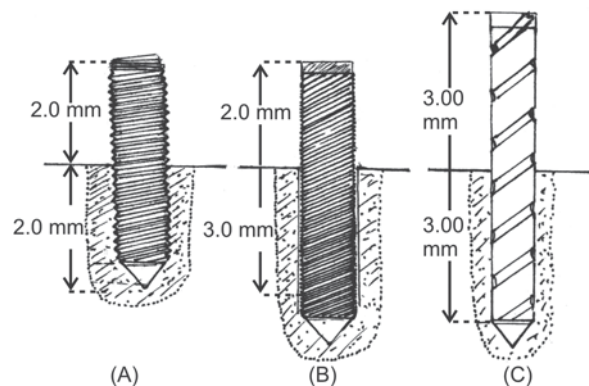
### INDICATIONS FOR PIN RETAINED RESTORATIONS

1. *Grossly mutilated teeth:* Large restorations may be fractured or may be lost due to occlusal loading. In cusplless vital teeth use of pins will provide retention and resistance. If endodontic treatment is indicated they must be placed in the start of the treatment, because pins facilitate in securing of the rubber dam clamp and provide the seal during root canal treatment.
2. *Extended preparations:* Pin placement is recommended if large interproximal restoration, restoration of cusp shapes or of cavity extended beyond the line angles, is to be done. Use of pin provides added strength when the margins of the restoration are not surrounded by enough tooth structure.

3. *Cores for full coverage restoration:* By pin-supported amalgam, core can be placed in less time and expense. The retention and seal produced by the pins preserve the tooth during the extra coronal restoration.
4. *Extensive class V restorations:* The success rate of extensive class V restoration is increased by the use of pins. Pin placement also tends to reinforce the restoration.



**Fig. 19.1:** For additional retention dentinal slot and lock surrounded by dentin with undercut are prepared for amalgam



**Fig. 19.2:** Types of pins (A). Self-threading (B). Cemented (C). Friction – locked

**Table 19.1:** Factors to be considered during placement of pin.  
Locations, areas to be avoided and angulations for pin placement

| MAXILLARY TEETH                                                               |                                                                                                                                                                                                                             |                                                                                                   |                                                                                                                                           |
|-------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Tooth                                                                         | Locations of pin                                                                                                                                                                                                            | Areas to be avoided                                                                               | Pins angulation                                                                                                                           |
| A. Central incisor                                                            | 1. Ideal location is gingival floor, close to proximo-labial and proximo lingual corner.<br>2. Middle of proximal gingival floor, or middle of labial gingival floor.<br>3. Incisal, where there is atleast 2 mm of dentin. | 1. Middle of lingual gingival floor.<br>2. Incisal in absence of sufficient dentin.               | 1. Proximal and labial pins should have slight labial inclination.<br>2. Gingival pins should have limited angulation.                    |
| B. Lateral incisor as overall dentin thickness is less pin should be avoided. | Same as central incisors.                                                                                                                                                                                                   | Same as central incisors.                                                                         | Same as central incisors except that gingival pins have slight more angulation.                                                           |
| C. Canine                                                                     | 1. At or close to the facio-and linguo-proximal corners of the tooth.<br>2. Middle of proximal gingival floor and middle of a labial gingival floor<br>3. Incisal, close to incisal angle.                                  | 1. Middle of lingual gingival floor.<br>2. Gingival pins close to surface concavities or grooves. | 1. Gingival pins should have slight labial angulation.<br>2. Incisal pins should be parallel to the adjacent proximal slope of the teeth. |
| D. Premolars                                                                  | 1. Close to the proximo-facial and lingual corner of tooth placed gingivally.                                                                                                                                               | 1. Mesial gingival floor.<br>2. Middle of gingival floor buccally and lingually.                  | 1. All gingival pins should be parallel to the long axis of tooth.                                                                        |
| E. First and second molars                                                    | 1. Gingival floor at or close to the disto-lingual corner<br>2. Gingival floor at or close to disto-buccal and mesio-lingual corner of tooth.                                                                               | 1. Gingival floor at mesio-buccal corner<br>2. Any part of gingival floor occlusal to furcation.  | 1. Gingival pins mesially and distally should be parallel to long axis of tooth.                                                          |
| F. Third molar                                                                | Pins are generally not placed because of variable anatomy of tooth. They can only be placed after radiographic evaluation                                                                                                   |                                                                                                   |                                                                                                                                           |
| MANDIBULAR TEETH                                                              |                                                                                                                                                                                                                             |                                                                                                   |                                                                                                                                           |
| A. Central Incisors and B. Lateral incisors                                   | As thickness of dentin is less the pins are usually avoided as retention means in these teeth except in aged teeth, where pulp chamber is calcified or has very much reduced.                                               |                                                                                                   |                                                                                                                                           |
| C. Canine                                                                     | Pin location and angulation are very similar to those of upper canine.                                                                                                                                                      |                                                                                                   |                                                                                                                                           |
| D. Premolars                                                                  | 1. Close to or at the proximo-facial and proximo-lingual corners of gingival floor or step                                                                                                                                  | 1. Middle of gingival floor, buccally and lingually.                                              | 1. Pin angulation should always be parallel to long axis of the tooth.                                                                    |
| E. First and second molars                                                    | 1. Distolingual corner gingival floor<br>2. Disto-buccal and mesio-lingual corner gingival floor.                                                                                                                           | 1. Mesio-buccal corner gingival floor.<br>2. Mesio-buccal to any cusp tip (Pulphorn)              | 1. Mesially and distally, gingival pins should be parallel to long axis of tooth.                                                         |
| F. Third molar                                                                | As maxillary third molar.                                                                                                                                                                                                   |                                                                                                   |                                                                                                                                           |

5. *Time period and Economic factors:* When there is no chance for second appointment or an economic problem regarding cast gold restoration, pin-retained amalgam restoration can be the restoration of choice.

## ADVANTAGES OF PIN RETAINED RESTORATIONS

1. *Conservation of tooth material:* For pin retained amalgam restoration, where (a) enamel is supported by sufficient amount of healthy dentin and (b) the area is not exposed to heavy masticatory forces, moderate amount of undercut can be given. Therefore, the preparation is more conservative than slot and lock preparation or tooth preparation for cast restoration.
2. *Number of appointments:* Only one appointment is required for pin retained restoration whereas for cast restoration, at least two appointments are required.
3. *Resistance and retention form:* Use of pin increases the resistance and retention of the restoration and requires minimum cutting of healthy tissues.
4. *Economics:* Pin restoration is relatively inexpensive, does not require laboratory facility and can be completed in single sitting compared to cast restoration.

## DISADVANTAGES OF PIN RETAINED RESTORATIONS

1. In pulpectomized and pulpotomized teeth: In such teeth elasticity of dentin gradually reduces. Therefore, pin-retained restorations are contraindicated because the chances of fracture of dentin increase due to its dehydration.
2. *Dental microfractures:* When minimal dentin is present, fracture lines in dentin or internal stress in dentin may be created while drilling pin holes or during pin placement.
3. *Microleakage:* Microleakage may occur around the pins if their ends appear on or near to the surface of the restoration.
4. *Strength of amalgam:* Pins decrease the tensile and transverse strength of amalgam while compressive strength is not increased.

5. *Perforations:* On misdirection of the bur or pin there is a risk of perforating into the pulp or the external tooth surface.
6. *Tooth anatomy:* In some cases it is not possible to achieve proper contours and occlusal contacts with pin retained restorations.
1. *TYPES OF PIN:* Self-threading pin is the most retentive, cemented pin is least retentive, while the retention obtained by friction-locked pin is intermediate. The retentive capability of cemented pin can be increased by increasing the depth of the pin within the dentin. Commonly pins are of the following types.

- a. *Self-threading pin:* For these pins the pinholes are slightly smaller (0.038 to 0.1mm) in diameter than the pin diameter. The pins are retained due to the mechanical grasp of the threads into the dentin. The viscoelastic property of the dentin allows insertion of a threaded pin into a hole of a smaller diameter.

Advantages of this type of pin are (a) superior retention, (b) less depth is required for placement and (c) no cementing medium is required. Disadvantages of threaded pin are that (a) the pulpal stress is maximum when the pin is inserted perpendicular to the pulp, and (b) stresses on dentin are also maximum.

- b. *Cemented pins:* For cemented pins, the prepared pinholes should be 0.025 to 0.05 mm larger than the diameter of the pin. The pin is checked for contour and length by placing in the tooth. If pin does not interfere with insertion into the pin hole and its length is correct then it is cemented with glass ionomer or zinc phosphate cement. The depth of hole in dentin should be 3 to 4 mm.
- c. *Friction-locked pins:* The diameter of the pinhole is 0.025 mm smaller than the diameter of the pin. By gentle tapping they are placed into dentin and are retained due to resiliency of dentin.

2. *PIN SIZE:* Pins are available in four sizes, each pin size is color coded.

| Name       | Color code | Pin diameter         |
|------------|------------|----------------------|
| A. Minuta  | pink       | 0.38 mm (0.015 inch) |
| B. Minikin | red        | 0.48 mm (0.019 inch) |
| C. Minim   | silver     | 0.61 mm (0.024 inch) |
| D. Regular | gold       | 0.78 mm (0.031 inch) |

Pin size is selected after considering the following factors:

## 202 Textbook of Operative Dentistry

- a. Amount of dentin present to receive the pin
- b. The amount or degree of retention required

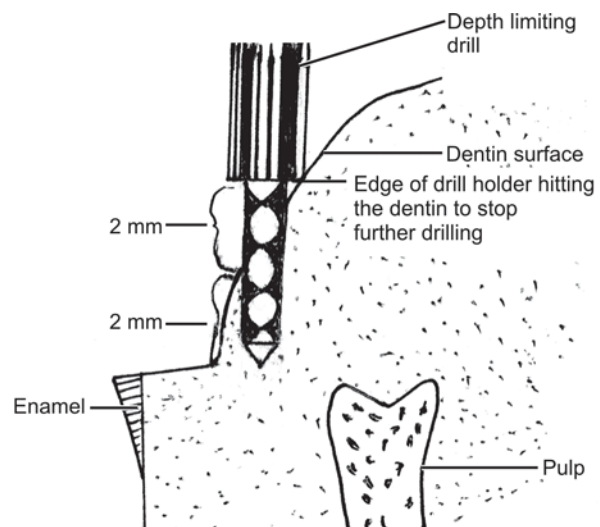
For most of the posterior restorations, minikin or minim size of pins are used depending on the available dentin. Regular sized pins provide the most retention and by increasing the depth, retention and resistance are increased. It is used for cross-splinting and extensive class V restoration.

3. **Number of pins:** Excessive number of pins should be avoided. The following are the disadvantages of the excessive pins.

Excessive number of pins (a) generate stress in the tooth which can fracture the tooth (b) decrease the amount of available dentin between the pins (c) decrease the strength of amalgam restoration.

As far as possible one pin must be placed for each missing cusp and one pin for each missing proximal surface. Certain factors may alter this rule. Due to esthetic considerations, instead of two small pins, one single large pin is more acceptable or if only 2 to 3 mm of occluso-gingival height of cusp is lost, there is no need for pin because it can be restored with conventional restoration.

4. **Length of pin into dentin and amalgam:** To retain the restoration and to resist occlusal forces, pin extension of 2 mm into dentin and amalgam provide maximum required retention. Pin extension greater than 2 mm is contraindicated to preserve the strength of dentin and amalgam. When pins are placed in cuspal coverage areas, they should project only minimally into the restorative material. Depth limiting drill should be used as much as possible (Fig. 19.3).
5. **Site of pin placement:** During site selection for pin placement the following factors must be considered.
  - a. Knowledge of normal pulp anatomy is essential to avoid perforations.
  - b. Pins should not be placed directly below an excessive occlusal load as it weakens the amalgam.
  - c. Pinhole should be at least 0.5 mm inside the dentin from the dentino-enamel junction to reduce the potential and chances for crazing of the tooth structure.
  - d. The pins should be positioned at least 0.5 mm from the external surface of the tooth to allow



**Fig. 19.3:** Use of depth limiting drill to prepare pinhole of limited depth in the dentin

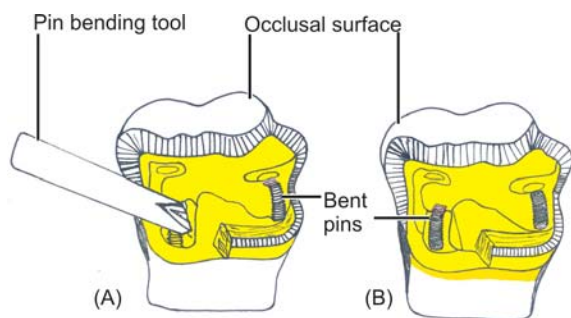
for adequate thickness and condensation of amalgam around the pin for maximum retention.

- e. As far as possible pinholes should be located on a flat surface, which should be perpendicular to the direction of the pinhole or on less angular surface.
- f. When more than two pinholes are to be made, they should be placed at different tooth levels. This helps in preventing the stresses in same transverse plane of the tooth.
- g. If two or more pins are to be placed, they should be kept apart because it results in lower levels of stress in dentin. The minimal distance is 3 mm for minikin and 5 mm for minim.
- h. Intermittent radiographic (preferably RVG) monitoring should be done constantly, while preparing a deep cavity and placing the pins
6. **Preparation of pinhole:** For making pinholes Kodex [twist] drill should be used. The drill is made of a high-speed tool steel that is swaged into a color coded aluminium shank. Omni-depth gauge is used to measure the depth of the pinhole. During drilling, tilting of the handpiece, or allowing the drill to rotate more at the bottom of the pinhole must be avoided as it results in a large hole.



From the time of insertion till removal, the drill must be kept continuously rotating only in one axis and one direction. This will prevent fracture of the drill in the pinhole and also excessive cutting.

7. **Pin design:** Pins are made up of titanium or stainless steel and are gold plated. Several pin designs are there for the various (four) sizes of pins. The available pin designs are (a) standard, (b) self-shearing, (c) two-in-one, (d) link series and (e) link plus. Sometimes bending of the pin may be required to position it between the contour of the final restoration and to provide bulk of amalgam between the pin and external surface of the final restoration. For bending of pins TMS bending tool is used (Fig. 19.4).

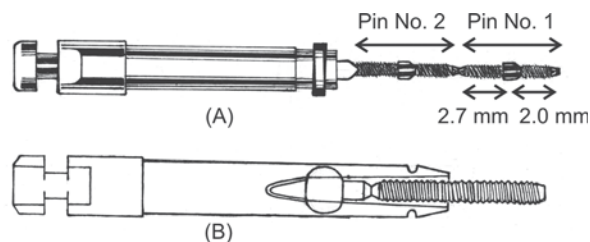


**Fig. 19.4:** (A). Remaining caries free crown of mandibular first molar TMS bending tool to bend the pin with one bent pin. (B) Pins are bent in position that provides bulk of amalgam between the pins and external surface of final restoration for strength

In Thread Mate System (TMS) pins two types of pins are used. They are (A) link plus pin (B) link series pin. In link plus pin system several pins are united together in the wrench. After inserting one pin it is cut from the joint with another pin which is used at another place. In link series pin system one pin is used in the TMS wrench at a time (Fig. 19.5).

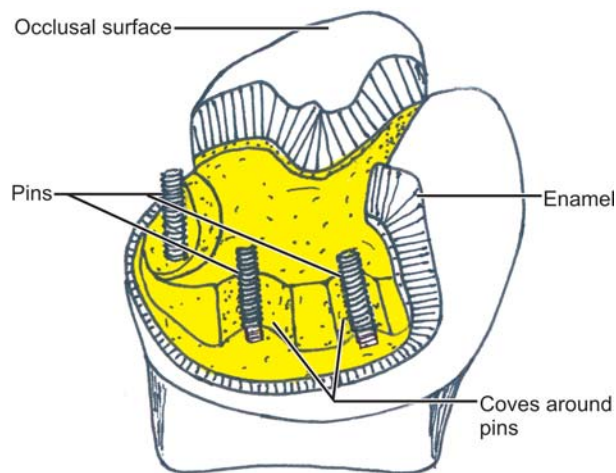
### CAVITY PREPARATION FOR PIN RETAINED AMALGAM RESTORATIONS

After the cavity preparation and excavation of carious dentin, rim (step, gingival step, or floor) preparation is done in the tooth, which should have shoulder finish. To facilitate the placement of amalgam matrix and to conserve the gingival enamel, squaring of the tooth is



**Fig. 19.5:** Thread mate system (TMS) pins. (A). Link plus pin (B). Link series pin (cross-section)

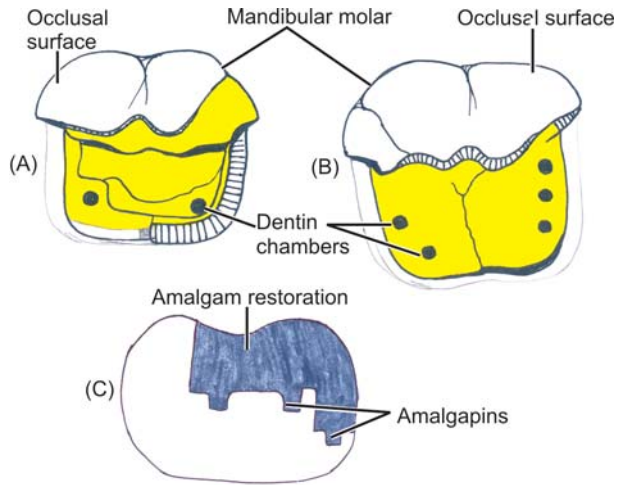
done to create room in the dentin for placement of amalgam matrix. After final preparation, base or liners are applied to reduce thermal conductivity and postoperative discomfort. Then pinholes for pins to provide resistance and retention are made. After placement of the pins, coves are prepared in axial wall of the cavity to provide adequate space for amalgam condensation around pins (Fig. 19.6).



**Fig. 19.6:** Coves prepared in axial wall of mandibular molar to provide adequate space for amalgam condensation around pins

### AMALGAPIN

Amalgapins are vertical posts of amalgam anchored in dentin. The pits prepared in dentin are shallow and little wider than pinholes and are called 'dentin chambers'. The post formed of the amalgam in the dentin chamber is called 'amalgapin'. They increase the retention and resistance. They also increase the bulk of amalgam. 'Dentin Chambers' for amalgam pin techniques also increase the bulk of amalgam (Fig. 19.7).



**Fig. 19.7:** Amalgapins technique (A) and (B) are occlusal view of preparation of “dentin chambers” for amalgapin technique. Positions of dentin chambers are relative to dentinoenamel junction and external tooth surface. (C) Buccal view of crown of first mandibular molar with amalgam restoration with amalgapins

## MATRIX PLACEMENT

In most of the cases, Tofflemire retainer and band are used. When Tofflemire matrix cannot be used, impression compound-supported copper band matrix may be used. Automatrix, which is a retainerless matrix system, can also be used.

### Placement of Alloy

Spherical or admixed high copper alloy is used as a filling material. Each increment of amalgam is properly condensed. Amalgam must be properly condensed around the pins. From the occlusal surface excess amalgam must be removed. Marginal ridge must be at the same height as the adjacent marginal ridge. With disoid and Hollenback carver, develop the anatomy by doing carving.

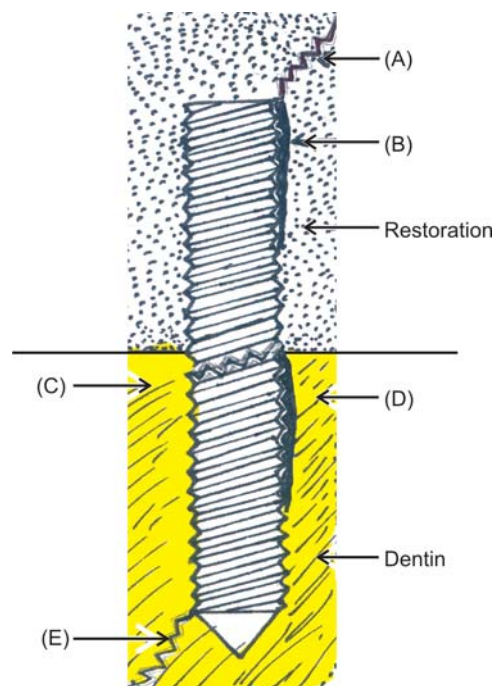
### Finishing and Polishing Procedure

Polishing must be done after 24 hours. The objective of polishing is refinement of the margins, development of the contour and smoothen of the surface. Round steel finishing bur or small wheel diamond is used to contour the occlusal restoration and to remove the oxides, which have been deposited on the carved surface. Silica or aluminium oxide is applied by prophylactic cup to polish the surface.

## FAILURE OF PIN RETAINED RESTORATIONS

The pin retained restoration may fail due to one of the following reasons.

- Within the restoration, fracture may occur. The cause may be improper condensation or improper trituration. Possible locations of failure of pin retained restorations and the tooth are shown in Figure 19.8.



**Fig. 19.8:** Possible locations of failure of pin retained restorations. (A). Fracture of restorative material. (B). Separation of pin from restoration (C). Pin fracture (D). Pin separation from dentin (E). Dentin fracture

- Separation at the interface of the pin and restorative material. The cause is the lack of proper condensation of the material around the pin.
- Broken pins and drills:** If drill is stopped before being removed from the pin hole or if it is stressed laterally during drilling, there are chances of breaking the drill. Pins may break during bending or if turned more than needed in the pin hole. Removal of broken pins and drills is difficult. Best is to choose another site about 1.5 mm away from the previous site and leave the broken pin as it is if it is not interfering in occlusion or condensation of amalgam.

- d. *Enlarged pin holes:* In some cases of self-threading pins, the pins are not properly engaged in the dentin because either the pinhole is too large or the pin failed to be driven in the pinhole resulting in stripped out or chipping of dentin or enamel. To stabilize the pin, one of the following four things can be done.
  - i. Drill the fresh hole and insert a fresh pin
  - ii. Redrill a larger fresh hole and insert the larger pin
  - iii. Cement the existing pin in place
  - iv. Drill another hole of the same diameter 1.5 mm away from the present hole and insert the same pin.
- e. Pulpal penetration and periodontal perforation.

If after removal of the drill from the pin hole there is bleeding then penetration into the pulp or periodontal perforation is obvious. In periodontal perforation bleeding will be more profuse. Penetration or perforation can be verified by radiograph. If pulpal penetration occurs and the tooth is asymptomatic, and if very little and fresh red bleeding is there, treat it by direct pulp capping and prepare another hole. If penetration into pulp occurs in teeth that had extensive restorations or caries, root canal treatment should be done.

If periodontal perforation occurs occlusal to the gingival attachment, pin can be cut off and flushed with tooth surface then prepare a cast restoration. Another method of management is to remove the pin, enlarge a pin hole and restore it with amalgam. If perforation occurs apically, surgically reflect the tissue, remove the bone, enlarge the pin hole and restore it with amalgam or with gold foil if possible.

For details or secondary (additional) retention and resistance forms and bonding of amalgam chapter nos. 8, 18 and 23 may be referred.

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The longevity of a restoration mainly depends on various factors, out of them following three are most important.

1. The properties of the restorative material; 2. The clinical acumen of the dental surgeon; 3. The patient's oral environment. The restoration deteriorates as time goes by, depending upon the dynamics within the oral environment. Several studies have shown that microleakage poses a great threat to the restored teeth. Microleakage may be defined as 'the ingress of bacteria, its products, toxins, molecules, oral fluids and ions between the margins of the restoration and the walls of the prepared tooth.' It can give rise to various implications which are as follows.

1. *Secondary/recurrent caries*: Lesions occurring along the tooth and restoration interface may be due to the penetration of bacteria which are less than 1.0 micron in diameter from gaps.
2. *Pulpal irritation*: It is more likely to be caused by bacterial toxicity than chemical toxins from the restoration. Inflammatory products enter the unprotected dentinal tubules via the marginal gaps and consequently harm the pulp (see Fig. 10.1).
3. *Postoperative sensitivity*: Leakage of materials causes a change in the local ionic concentrations. Fluid movement from leaky margins in the dentinal tubules causes pulpal pain and dentinal sensitivity. This is more commonly associated with proximal and cervical cavities at the gingival wall restored with resins.
4. *Marginal discoloration*: The microleakage in esthetic restorative materials leads to the formation of a boundary around the restoration. This is due to the accumulation of subsurface interfacial stains and should be replaced promptly.
5. *Dissolution of luting cements*: Luting cements may get rapidly dissolved due to marginal leakage.

### **Smear Layer**

Whenever tooth preparation ensues, a 'Smear Layer' of residual organic and inorganic components or debris is formed. This 1 to 2 micron thick layer may also fill

the orifices of dentinal tubules upto 1 to 5 micron forming 'smear plugs'. This reduces the permeability of dentin and protects the pulp. Removing the smear layer and plugs if they are near to pulp, may interfere with adhesion due to an increase in the dentinal fluid flow. If they are away from the pulp where dentinal fluid is much less, removal of smear layer increases surface area and retention and reduces microleakage. However, the role of smear layer is controversial in causation of microleakage (see Figs 10.2 and 10.3).

### **MICROLEAKAGE AND RESTORATIVE MATERIALS**

The dominant factor that controls the performance during the early life of the restoration is the material itself apart from the operator's skill. Microleakage is an indication of microscopic gaps between the tooth surface and the restoration. The restorative material should provide a perfect marginal seal to prevent microleakage. Properties like creep, elasticity, solubility and resistance to fatigue contribute in a minor way to microleakage, while coefficient of thermal expansion, polymerization shrinkage and adhesion affect microleakage in a major way.

1. *Coefficient of thermal expansion (CTE)*: It is the change in length per unit length of a material by per degree change in temperature. Every time a restoration undergoes a wide temperature change within the oral cavity (such as drinking tea or having ice-cream), it also undergoes a volumetric change of varying magnitude than that of the tooth structure. Accordingly, microleakage ensues around dentin margins as potentiated by the discrepancy in linear coefficient of thermal expansion between the restoration and the tooth substance. Thus an ideal restorative material is one whose CTE matches that of tooth substance. Greater the difference between CTE of tooth substance and restorative material, greater will be the microleakage (see Table 10.1).



2. *Polymerization shrinkage*: Composites shrink as they polymerize, creating stresses which cause marginal leakage. If the contraction stresses generated are very high, the intermediate adhesive resin (used to bond resin to tooth) may also pull away from the cavity walls, promoting microleakage (see Table 10.2).
3. *Adhesion*: It is the attraction between the molecules of two different substances, being influenced by surface energy. Wettability, presence of smear layer, surface roughness and lack of adhesion may give rise to microleakage. Microleakage is also influenced to a great extent by the operator's skill. Improper cavity preparation, poor condensation or packing procedures, inadequate cavosurface margins, improper isolation, unfinished margins of a cast inlay, improper fit of crowns exposing a thin cement line all contribute to microleakage.

## METHODS TO DETECT MICROLEAKAGE

The *in vitro* and *in vivo* methods have demonstrated various ways to detect microleakage. However, none of the following methods is perfect.

1. *Dye method*: In these studies the marginal integrity of various restorative and cementing materials was tested by immersing the test teeth in various dye solutions for a variable period. The assessment of marginal seal was done on the basis of its ingress in and around restorative materials. They are available as solutions or particle suspensions. Most frequently used dyes are as follows: (a) Methylene Blue (b) Crystal Violet (c) India Ink (d) Eosin (e) Erythrosin (f) Fluoroscein (g) Basic Fuchsin (h) Rhodamine B.

Their disadvantages are as follows: (a) Results obtained are not consistent (b) Dyes may not be color stable (c) If the dye binds to the tooth or to the restoration it is a source of error.

2. *Radioactive isotope method*: Methods using radioactive isotopes are believed to be more sensitive as they can penetrate and detect even minute amount of microleakage. The following isotopes are commonly used—(a)  $^{14}\text{C}$ , (b)  $^{32}\text{P}$ , (c)  $^{35}\text{S}$  (d)  $^{45}\text{Ca}$  (e)  $^{86}\text{Rb}$  and (f)  $^{131}\text{I}$ . Disadvantages comprise of—(a) Results have to

be assessed subjectively (b) Isotopes are expensive and technic sensitive (c) Some isotopes (e.g.  $^{45}\text{Ca}$ ) may bind to tooth structure and give false results (d) Special chambers are required and special precautions have to be observed.

3. *Chemical tracer method*: They involve the use of two colorless compounds which react to produce an opaque precipitate. Usually a 50% Silver nitrate solution is reacted with Hydroquinone (Benzene 1, 4 -diol). Sometimes 1% Silver chloride is also used.

Other methods to detect microleakage include the following:

4. Neutron activation analysis.
5. Scanning electron microscopy.
6. Bacteriological method.
7. Air pressure technique.
8. Artificial caries-using acidified gelatin gel technique.
9. Electrochemical studies.
10. Reverse diffusion method.
11. Pain perception.

## MICROLEAKAGE IN AMALGAM RESTORATIONS

Exceptionally fine clinical performance of amalgam is linked to its tendency to minimize marginal leakage due to aging. Amalgam restoration is unique in being gradually a 'self-sealing' restoration. In a properly inserted restoration, leakage decreases with age, due to the corrosion products sealing the interface between the tooth and restoration. In low copper alloys, corrosion products consist of the oxides and chlorides of tin. However, in high copper alloys microleakage continues for a longer time period due to a greater resistance to corrosion and a decreased rate of formation of corrosion products. Microleakage due to dimensional changes in amalgam is nearly minimal.

### Methods to Prevent Microleakage in Amalgam

The following factors affect the marginal leakage.

1. *Type of alloy*: Lathecut or Admixed alloys display less microleakage than spherical alloys. Thus lateral condensation should be used for spherical alloys. Alloys with lesser creep values have less leakage. Creep value for low copper alloys is 0.8 to 8.0 percent and for high copper alloys is 0.1 to 1 percent.



2. *Condensation*: Hand condensation is inferior to pneumatic condensation. Condensation should be performed without any delay after trituration, otherwise there are increased chances of void formation. Small increments of amalgam should be condensed using an optimal pressure of 4 kg (10 pounds) for a 2 mm condenser point, moving from the center to the periphery using a stepping process aiding adaptation.
3. *Burnishing*: Degree of microleakage varies with particle shape of amalgam. Burnishing does not reduce leakage in spherical alloys.
4. *Use of liners/varnishes*: Due to their solubility in mouth, varnishes are effective for a duration of six months. However, this time period is sufficient for corrosion products to form and seal the microspace. Glass ionomer liners also reduce microleakage significantly. Amalgam bonding agents, have been found effective in reducing microleakage.
5. *Sealed amalgam restorations*: In this etching of adjacent enamel is done to coat an unfilled resin, over the amalgam restoration and adjacent enamel. Duration of resin wear may correspond with formation of corrosion products, hence minimizing leakage.
6. *Gallium amalgam*: Amalgam of Gallium-Tin-Indium (liquid) and a silver based alloy (powder) are similar in their composition to high copper amalgam alloys. They have a very high wetting ability, which causes the final restoration to be highly resistant to microleakage.

## MICROLEAKAGE IN DIRECT GOLD RESTORATIONS

Direct gold restorations show little or no microleakage due to their good adaptability to the prepared cavity. Microleakage is also reduced due to its complete insolubility in oral fluids, high malleability and ductility which facilitate self burnishing and contouring. Also the elastic compression of the underlying and surrounding dentin during condensation prevents leakage.

### Methods to Prevent Microleakage in Direct Gold Restorations

1. The internal bulk of the restoration should be formed from porous mat and powdered gold, and cohesive gold foil should be put on surface as a veneer.

2. For a 2 mm condenser point an optimal pressure of 4 kg should be applied for proper condensation.
3. Uniform stepping should proceed from the center to the periphery with the build up of restoration in a convex form.
4. Condensing force should be directed at right angles to pulp in the center and at 45 degree near the periphery.
5. Burnishing, finishing and polishing improve the marginal seal and hence prevent leakage.

## MICROLEAKAGE AND CAST RESTORATIONS

The gap between cast restoration and the prepared tooth (10 to 160 micron) is filled by a low viscosity luting cement. This helps in proper retention and sealing of the interface. However, it is this intermediate cement which causes microleakage if their solubility is greater than 0.04 to 0.10%. Thus if zinc phosphate, silicate or silicophosphates are used burnishing should be done after 24 hours so that few superficial microns of the cement layer have been removed and metal margin can be burnished.

### Methods to Prevent Microleakage in Cast Restorations

1. Close fitting restorations should be prepared.
2. Tooth should be designed adequately with optimum taper, so that it prevents rotation and subsequent fracture of the restoration.
3. In case of gold, the placement of bevels and burnishing of margins physically closes all marginal discrepancy.

## MICROLEAKAGE INVOLVING GLASS IONOMER RESTORATIONS

Glass Ionomer is hydrophilic in nature hence it can chemically adhere to the tooth even in presence of moisture. Its CTE is closer to that of tooth, and it is fluoride releasing. It is technic sensitive and soluble during setting hence should be isolated for at least 30 minutes after placement to prevent solubility. Resin modified glass ionomer cements because of polymerization shrinkage show greater microleakage than those chemically cured.

### Methods to Prevent Microleakage in Glass Ionomer Restorations

1. *Bonding*: Conditioning of tooth with tannic acid, polyacrylic acid or citric acid increases bonding and reduces microleakage.
2. *Powder*: Liquid Ratio–Lower powder: liquid ratio increases solubility of cement. Hence material should be manipulated properly.
3. Rotary instruments should be used for finishing the restoration as hand instruments may cause marginal ditching.
4. Vaseline or petroleum jelly should be coated on restoration surfaces, during finishing. This prevents any desiccation or moisture contamination which could cause microleakage.

### MICROLEAKAGE AND COMPOSITE RESTORATION

Microleakage is a problem in almost all composite restorations. It is due to the fact that they are extremely technical sensitive. The CTE of Composite is also higher than that of tooth,  $22$  to  $55 \times 10^{-6}$  per degree centigrade) causing microleakage. The polymerization shrinkage leads to the development of stresses which usually lead to marginal leakage, as the bond to dentin is weak. Also occlusal stresses enhance microleakage due to repeated deformation of the restoration. The microleakage is greater on cervical margins of class II restorations.

### Methods to Prevent Microleakage in Composite Restorations

1. *Choice of material*: Greater flexibility of microfilled composite resins than macrofilled composite resins helps to prevent microleakage.
2. *Cavity preparation*: The size and shape of the cavity should be as conservative as possible. Rounded internal line angles, reduced depths and placement of bevels on facial and lingual margins of proximal box prevent microleakage to a considerable extent.
3. *Acid etching and bonding*: Acid etching on thicker enamel provides micromechanical interlocking which reduces microleakage. Since cervical enamel is thin, gingival margins are more prone to leakage. Dentin bonding agents promote close adaptation between the resin and treated dentin. Dentin

bonding systems that etch deeper, however, show higher degrees of nanoleakage. Nanoleakage occurs within the nanometer sized spaces, which are around the collagen fibrils. These are present in the hybrid layer and are not completely filled by resin. Recently new materials have been developed which have better sealing properties.

4. *Cavity liners and bases*: Glass ionomer cements and calcium hydroxide are used as bases under composites. They protect the pulp, reduce the bulk of composites and thereby reduce polymerization shrinkage. In addition, glass ionomers bond strongly to dentin.
5. *Filling of cavity*: The cavity should be filled by placing multiple increments of resin  $1.0$  to  $1.5$  mm in thickness. A decreased resin to filler ratio should be used, to minimize polymerization shrinkage and microleakage.
6. *Curing*: The polymerization shrinkage of setting composite resins are directed towards the light source. Hence for better adaptation of class II conventional composite restorations a three sided curing technic is used: two, one each from middle of buccal and lingual surfaces and third from gingival third of buccal side. Prolongation of curing time of a composite resin prevents microleakage as it allows a greater inversion rate of the monomer component. To further reduce microleakage, marginal gaps should be sealed by using pit and fissure sealants.
7. *Finishing*: Increased leakage occurred on using high speed rotary instruments while slow speed with light brush strokes or use of sofex discs provided better marginal adaptation. Much less microleakage results if finishing was done on the next day of insertion.
8. If microleakage is more composite inlay restorations may be used.

### MICROLEAKAGE AROUND PORCELAIN RESTORATIONS

Proper bonding of ceramic inlay to the tooth requires resin luting agent. The inlay surface is etched by hydrofluoric acid or ammonium bifluoride to improve micromechanical retention. Silanating agents improve retention. However, interfacial gaps between the inlay and tooth surface may promote microleakage and marginal staining.

### Methods to Prevent Microleakage

1. Precise fabrication of restoration is must. Closer fit reduces microleakage.
2. Resin cements preferably dual cure should be used to improve bonding.
3. The mechanical and chemical treatment of the inlay surface should be optimum to prevent microleakage and promote adhesion.

The use of RMGI (Resin Modified Glass Ionomer) restorative materials in Class V cavities permit immediate finishing and reduces the rate of microleakage. These materials should be dry finished with abrasive disks to provide a smoother surface without increasing the risk of microleakage. Conventional glass ionomer materials should be wet finished to prevent desiccation.

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# 21

## *Finishing and Polishing of Restorations*

Finishing and polishing are the measures undertaken in the restorative procedure to obtain a smooth, shiny surface of a restoration, keeping in mind esthetics and maintenance of periodontal tissues in healthy condition. Finishing and polishing are the important steps in any restorative procedures, they make the surface of a restoration smooth and shiny, thus reducing the chances of plaque accumulation, which may lead to gingival inflammation and secondary caries. 'Finishing' means removal of surface irregularities, in order to transform an object from rough to a refined form. Polishing can be defined as creating a surface layer which can reflect light as good as enamel surface. This can be obtained with the help of polishing materials used during the procedure that fill microscratches and produce a perfectly smooth surface. 'Buffing' refers to a polishing procedure in which abrasives are applied via bristle brushes, treated leather and cloth materials.

Finishing can also be done by cutting and/or grinding away the substrate particles. In addition to cutting and grinding, there are some other procedures by which we can obtain a smooth and shiny surface.

### **BURNISHING**

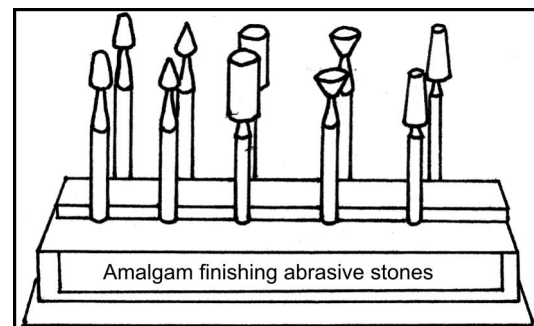
Burnishing is an essential part of fabrication of all metallic restoration. It can be defined as a process of rubbing a smooth metal instrument over the restorative material to make it shiny or lustrous. Numerous types of burnishers are used for this purpose. Their nib can be ball-shaped, oval-shaped, pear shaped, egg-shaped, apple-shaped, beaver-tail-shaped, conical-shaped, etc. There are burnishers for specific operations, e.g. spartley's burnishers, which are used for proximal gingival marginal burnishing of metallic restorations.

Burnishing in amalgam restoration is carried out with the help of large rounded burnisher, used in light strokes, proceeding from the amalgam surface to the tooth surface on the occlusal and other conspicuous

portions of the restoration. This process is a continuation of condensation, with the help of which we can reduce the size and number of voids on the critical surfaces and marginal areas of the amalgam. Burnishing brings excess mercury to the surface, to be discarded during carving and also adapt amalgam further to cavosurface anatomy.

### **FINISHING AND POLISHING DEVICES**

1. *Finishing burs:* Finishing burs are made up of stainless steel (for amalgam) or tungsten carbide (for composite resins). They do not grossly cut the restorative materials but only remove excesses, creating a smoother surface. They should have at least 12 flutes. They are available in various shapes and sizes, like round, oval, flame shaped, pear-shaped, tapered, inverted cone, etc (Fig. 21.1).



**Fig. 21.1: Instrument kit for finishing amalgam**

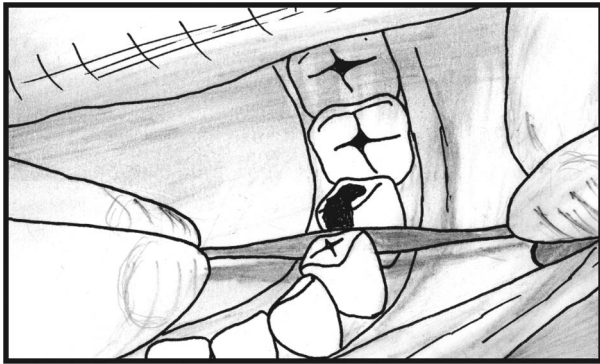
2. *Rubber instruments:* Rubber ended rotary tools are essential for any polishing procedures. They are used with the abrasive or polishing pastes and can be attached to the handpiece. They are available in variety of shapes and sizes, e.g. cups, wheels, cones, round, oval, flame, etc.
3. *Brushes:* Brushes can be used alone or with abrasive paste. They can be screwed in mandrel or can be mounted and used in the handpiece. Most of the brushes have synthetic bristles, but some may have



## 212 Textbook of Operative Dentistry

very fine soft wire bristles for polishing cast restorations. They come in different forms, e.g. wheels, cylinders, cones, etc.

4. *Coated discs and strips*: The abrasive particles such as sand, cuttle, garnet are glued to paper, cloth and thin steel discs or strips. The strips are used by hands in back and forth motion. The disks are mounted on mandrel and used in handpiece (Fig. 21.2).



**Fig. 21.2:** Inter-proximal metal strip coated with abrasive is used for finishing inter-proximal areas of restoration

5. *Cloth*: Cloth of various softness is carried on a metal wheel or cone, and is used in the final stages of polishing, either with or without a polishing medium. It is rotated on a handpiece in slow speed.
6. *Felt*: They are used to obtain lustre for different metallic restorations. Felt are made up of compressed wool or synthetic materials in various sizes and shapes like wheels, cones and cylinders.

### FINISHING AND POLISHING MATERIALS

Various abrasives are used as finishing and polishing materials. They are as follows.

1. *Diamond*: Diamond is the hardest and having least wear rate among all the materials. It can abrade all materials hence called as 'superabrasive'. In dental practice, diamond is the most effective abrasive, especially for enamel.
2. *Synthetic diamond*: Synthetic diamond is produced by heating graphite at or above 2000°C under a pressure of 90 kilograms in presence of catalyst. These are used as abrasives for manufacturing diamond abrasive points, burs, wheels, saws, etc.
3. *Tungsten carbide (TC)*: Tungsten carbide is slightly less hard than diamond and is used for making various cutting tools used in industry and dentistry.

4. *Silicone carbide or carborundum*: Silicone carbide or carborundum is very hard and brittle abrasive. It is synthetic and is manufactured by fusing sand and coke at 2000°C. Its cutting efficiency is low. Its bonding disintegrates at very high speed because of rise in temperature. Hence, coolant should be used for good results. Carborundum is used in manufacture of grinding stone of different sizes and shapes and, abrasive points of different sizes and shapes, abrasive paper, cones and cloth discs.
5. *Alumina*: Alumina is used to manufacture coated and bonded abrasive, etc. white wheel stones and grinding stones used for grinding and finishing ceramic metal alloys are made up of sintered aluminium oxide.
6. *Garnets*: Garnets are usually dark red in color and are silicates of aluminium, cobalt, iron, magnesium and manganese and are very hard. They are used in grinding metal alloys and plastics.
7. *Pumice*: Pumice is a siliceous material and light yellow or light gray in color. It is used for polishing natural teeth, restorations, acrylic denture and appliances, etc.
8. *Chalk*: White or precipitated chalk is calcium carbonate which is a very fine white abrasive used for soft metals, acrylic resins, enamel, amalgam and gold foils. Chalk is used as mild abrasive in toothpastes and powders.

In addition to above mentioned abrasive materials, there are many others, which are used for finishing and polishing like quartz, sand, tin oxide, cuttle, zinc-oxide, kieselguhr, etc.

### Air Dispersed Hazards of the Finishing Process

While finishing appliances and restorations shaving, filings, and other minute particles mostly of solids and occasionally of pastes and liquids are generated. They are called 'dental aerosols'. They may also contain infected tooth structure and dental materials. If inhaled or swallowed or if it enters in the eye, it may be harmful and may give rise to disease of the throat, lungs and eyes.

Silica based materials are sometimes used for finishing and polishing, which if inhaled, are very harmful and may give rise to silicosis or grinder's disease. During cutting of amalgam, high temperature, that is generated may form mercury vapor, which if inhaled may lead to alveolar irritation and tissue reaction.



## FINISHING AND POLISHING OF AMALGAM RESTORATIONS

Finishing and polishing procedures allow proper shaping of contours and occlusion and provide a better marginal adaptation by removing excess amalgam from the margin that could otherwise fracture leaving a ditch between the tooth and the restoration. A smooth surface without irregularities minimizes the risk of tarnish and corrosion and is also esthetically acceptable.

Finishing and polishing of amalgam restoration is done after the carving is completed. Occlusal relationship of the restoration is assessed by asking the patient to close very lightly, stopping when any contact is noted, if space is seen between the adjacent teeth and their opposing teeth, the area of premature occlusal contact on the amalgam should be identified and relieved. After the occlusion is adjusted, the discoid and cleoid finishing instruments can be used to smoothen the accessible areas of the amalgam. Final finishing and polishing procedures for amalgam restorations are not attempted within 24 hours of insertion, because crystallization is not complete. After 24 hours, the surface of the restoration is usually rough due to heterogeneous structure of amalgam on setting. Now, finishing is done with the help of steel finishing bur or green carborundum stone. Guard against reducing any centric holding area. After the stone is used, the margins should be re-evaluated with an explorer tine. If no discrepancy is detected, the area may be further smoothed using light pressure with a suitably shaped round finishing bur. A smooth surface should be achieved before the polishing procedure is initiated.

Polishing is done with the help of coarse, rubber abrasive point at low speed and air-water spray to produce an amalgam surface with a smooth, shiny appearance. Polishing should be done at low speed due to danger of excessive temperature rise of restoration and the tooth, which may cause irreparable damage to the pulp or restoration or both. When overheated, the surface of the amalgam will appear cloudy. This cloudy appearance indicates that mercury has been brought to the surface, which results in corrosion of amalgam and loss of strength. After the area is washed free of abrasive particles, a high polish may be imparted to the restoration with a series of medium and fine-grit abrasive points. As an alternative to rubber abrasive points, final polishing may be accomplished using a rubber cup with

flour of pumice followed by a high luster agent, such as precipitated chalk.

## FINISHING AND POLISHING OF COMPOSITE RESINS

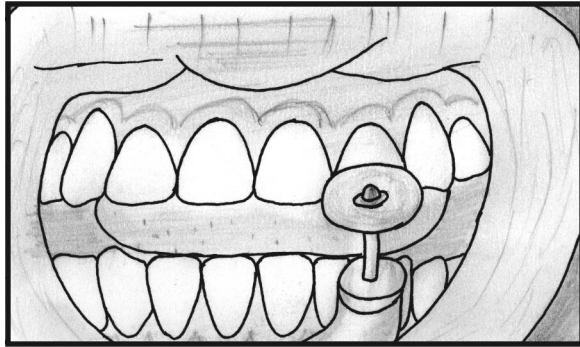
Composites are mostly used for the anterior restorations, thus finishing and polishing procedures are mandatory for their surface quality and natural appearance of the final restoration. Typically, the restoration is produced by intentionally overfilling the tooth preparation by a small amount. The anatomic contours are accomplished by grinding, finishing and polishing the material after polymerization. Effectiveness of restoration finishing and polishing procedures depends on careful use of successively finer abrasive materials to eliminate larger scratches or defects. Surface roughness can be measured with the help of profilometers (e.g. surfanalyzer) or atomic force microscopes (AFM).

Conventional composites pose greatest difficulty in achieving a smooth surface because of difference in hardness of organic and inorganic phases. Microfilled composite materials can be polished to the highest gloss and are considered to be esthetically best among all composites. Contouring can be initiated immediately after a light-cured composite material has been polymerized.

The occlusal surface is shaped with round carbide finishing bur. Special carbide-tipped carvers are used for removing excess composite along the margins. Finishing is accomplished with appropriate polishing cups or points after the occlusion is adjusted. Rotary instruments should always be used with a stream of water and little pressure. A final lustre is obtained with polishing pastes that may contain pumice, silica, alumina, tin oxide, etc. The paste is applied to the restoration with the help of brushes, rubber cups or dental tapes. After the final polishing of the composite is completed, a thin layer of glaze may be applied to improve surface smoothness (Fig. 21.3).

## FINISHING AND POLISHING OF DIRECT GOLD RESTORATIONS

The first step in the finishing process is to burnish the gold. This is done with the help of flat beaver-tail burnisher which is used with heavy hand pressure to

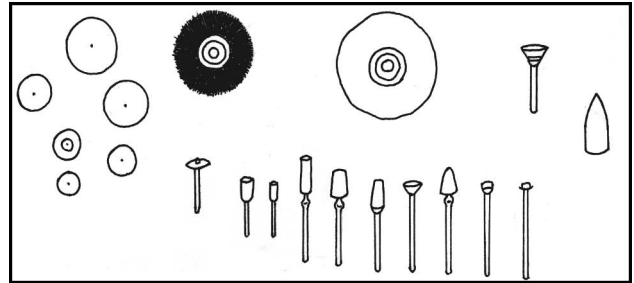


**Fig. 21.3:** Finer finishing of composites with finishing disk

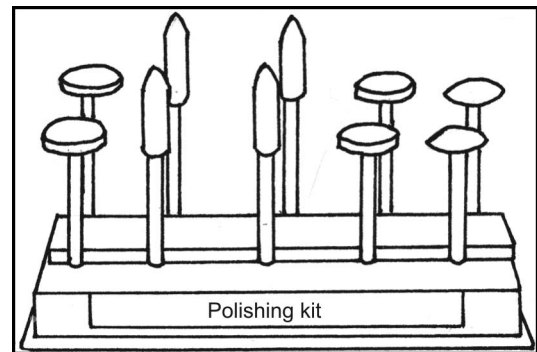
harden the surface gold. A cleoid-discoid carver is used to continue the burnishing process and remove excess gold on the cavosurface margin. After use of the cleoid-discoid, a small round finishing bur is used to begin polishing. Then a flour of pumice and tin oxide is applied dry, with a help of soft-rubber cup in slow speed handpiece. When removing excess gold over the gingival margin, care should be taken not to remove the cementum or ditch the root surface.

## FINISHING AND POLISHING OF CAST GOLD RESTORATIONS

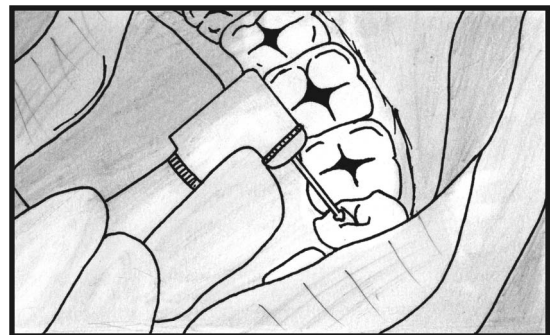
Casting is separated from the investment and is closely examined, to look for any surface irregularities, if present remove them with an appropriate sized round bur in the slow speed handpiece. Try the casting on the die, before removing the sprue and sprue button, if casting is not properly seated, then remove the small defects present on the surface of casting. If casting is properly seated on a die, then remove the sprue as close as possible to the surface with the help of carborundum separating disk. Now burnish the metal seated on the die with help of ball burnisher; this improves the marginal adaptation and smoothens the surface. A casting must not be loose on the die. If the casting is properly fitting, remove the remaining sprue metal with a carborundum disk. Check the occlusion of the casting by marking the occlusal contacts with articulating paper. Correct any premature contacts and refine their locations by selective grinding. The grooves, pits and other inaccessible regions are smoothed by rubber, abrasive points. Then polish the occlusal surface of the casting with soft bristle disk and tripoli polishing compound. Clean the polished casting



**Fig. 21.4:** Finishing and polishing instruments for amalgam and cast gold restoration

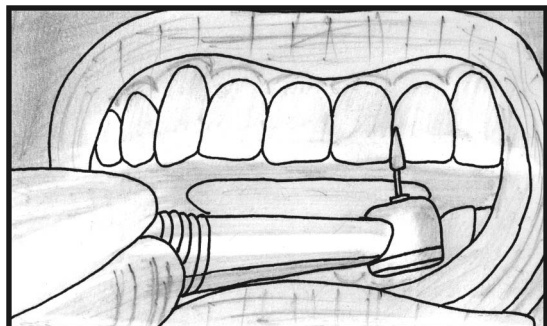


**Fig. 21.5:** Polishing kit for amalgam and cast gold restoration

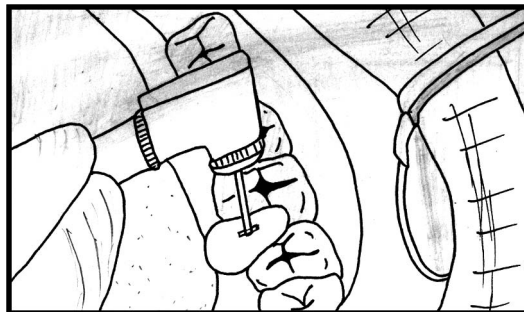


**Fig. 21.6:** Initial finishing with diamond bur

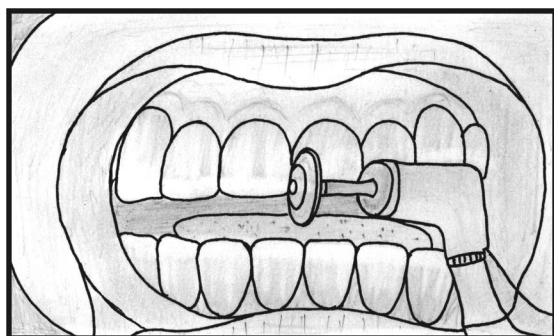
of polishing compounds by immersing the die with its casting in a suitable solvent for a minute or two, or by scrubbing with a soft brush and soap and water. Rinse, and then remove the casting from the die. During trial in patient's mouth high points if any are removed. Necessary finishing, if required is done before cementation. Final polishing is done after 24 hours of the cementation (Figs 21.4 to 21.9).



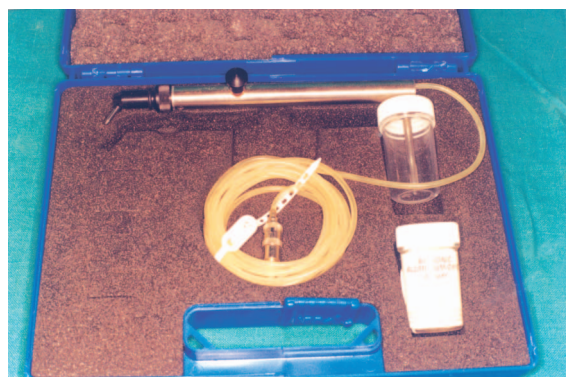
**Fig. 21.7:** Finishing of composites with silicone green stone



**Fig. 21.9:** Finishing with rubber disk



**Fig. 21.8:** Final finishing of composites with rubber disk and softlex disk (aluminium oxide polishing disk)



**Fig. 21.10:** Intraoral sand blaster

### Intraoral Sand Blaster

It is used for finishing and polishing of ceramic and metal inlays, crowns and fillings intraorally. In this Aluminium oxide ( $\text{Al}_2\text{O}_3$ ) powder is used (Fig. 21.10)

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Interim restorations are temporary or semipermanent restorations which are temporarily used or inserted, cemented or filled until a well planned, designed restoration is permanently inserted or cemented. Interim restorations are used to protect or treat the pulp, dentin and enamel surfaces and prevent supra eruption of the teeth till the permanent restoration is ready, for relatively shorter period of time.

### NEED AND USE

Occasionally it has been observed that patients neglect the teeth until and unless they are not able to use both the sides of the teeth. Such patients require complete mouth rehabilitation and extensive treatment so that the teeth can be preserved and can be made functional for years to come. During complete mouth rehabilitation and extensive treatment plans in oral cavity requiring lengthy treatment of several teeth involving multiple quadrants, judicious sequencing is important so that one side of the teeth can be made useful immediately so that patient can start using that side. On the other side of the upper and lower teeth well planned, proper treatment is carried out. On the side of the teeth where treatment is not carried out and on the side of the teeth where treatment is carried out between the visits some type of temporary restorations are given so that patient can use teeth as much as possible under these circumstances and further damage to the teeth can be stopped. These interim restorations enhance the confidence and motivation of the patients so that proper treatment can be carried out (Table 22.1).

The interim or temporary restorations should have the following properties.

1. Nonirritating and protecting the prepared tooth specially dentin and pulp.
  2. Protecting and maintaining the health of periodontium.
  3. Maintaining the position of the prepared, opposing and adjacent teeth.
  4. Provide functions of teeth like esthetic, phonetic and mastication, etc.
  5. Sufficient strength to withstand the usual forces in the oral cavity.
- These interim restorations are done with temporary or semi-permanent materials. These materials should have following properties.
1. Least marginal leakage
  2. Economically priced
  3. Easy and quick manipulation, placement and removal
  4. Fast setting
  5. Good compressive and reasonable tensile strength
  6. Insolubility in oral fluids
  7. Dimensional stability
  8. Sedative to pulp and periodontium
  9. Without any taste or odor
  10. Esthetically acceptable.
- Interim restorations can serve the following purposes:
- a. It can protect the pulp by acting as a barrier to the ingress of oral fluids which may act as an irritant to the pulp.
  - b. It can be a sedative for a hyperactive pulp which may be due to caries or due to cavity preparation.
  - c. It can be an indirect pulp cap as it creates a favorable biologic environment.
  - d. It maintains the position of the tooth in the arch by preventing overeruption and mesial or distal drift.
  - e. It protects the gingival tissues surrounding the tooth from inflammation by food impaction during mastication.
  - f. In open cavities, it works as a stop-gap measure.
  - g. To protect the tooth structure which may be weakened due to cavity preparation.
  - h. To protect the cavosurface margins after cavity preparation.
    - i. To restore the esthetics
- Interim restoration, if placed sub-gingivally, can cause gingival irritation. So the margins of the temporary restoration should not extend apically to the cavity preparation. The surface of the interim restoration should be smooth because rough or porous surfaces

have the potential for plaque accumulation. Interim or temporary restorations can be broadly divided into protective restorations and treatment restorations.

## PROTECTIVE RESTORATIONS

Mostly operative procedures are not completed in one visit. Hence for inter appointment period protective interim restoration is required.

The objectives for protective restorations are the followings:

- i. To reduce the tooth sensitivity after the initial cavity preparation.
- ii. To maintain the occlusion and to prevent the eruption of tooth if occlusal reduction is done.
- iii. To protect the gingival tissues from being inflamed.
- iv. To give an esthetic look.
- v. To prevent the integrity of weakened cavosurface margins and tooth tissue after reduction.

The various types of protective restorative materials are (A) Cements, (B) Crown forms, (C) Customized acrylic restorations.

The material is selected according to the number of teeth, inter appointment time period, type, location and extent of the cavity and esthetic demand.

## ZINC OXIDE EUGENOL (ZnOE) CEMENT

Many cements may be used for temporization, but mostly zinc oxide-eugenol cement is used because of ease of preparation, minimum marginal leakage, retention of dressing and esthetic consideration. Zinc oxide eugenol cement has a sedative effect on the dental pulp and provides an excellent seal of the cavity, if placed in a cavity with adequate resistance and retention form. A regular mix of zinc oxide eugenol cement is used for small, protected areas, but before placing the cement in the cavity, the prepared cavity must be isolated and cleansed. Few fibers of cotton, to act as a binder may be mixed into the mix after proper consistency is developed. Use of reinforced zinc oxide eugenol cement (IRM) has proved effective in temporization. In zinc oxide eugenol cement, zinc acetate crystals or water act as an accelerator of the setting.

## CROWN FORMS

There are various technics for the fabrication of interim crowns. Stainless steel, plastic, tin and aluminium are

commonly used for fabrication of temporary crown restorations.

- A. *Stainless steel readymade crowns*: The metal crown forms are primarily used for the posterior teeth. The crown is selected according to the gingival diameter and the metal is made to contact all around the gingival line of the tooth in the gingival space. Metal restorations help in the maintenance of vertical dimension. Some workers have recommended low strength ZnOE cement for cementing the crown. Considering the risk of swallowing it is better to cement with media having good compressive strength like zinc phosphate cement and remove them with crown remover whenever required. Stainless steel readymade crowns are also used as semi-permanent restorations in deciduous molars.
- B. *Aluminium shell crowns*: They are softer and weaker than stainless steel crowns and are also used for posterior teeth. An aluminium shell is adapted to the preparation and to secure the shell, luting media is placed in the shell. To enhance retention for patients with reduced interocclusal distance, resin mixture is placed within the shell. The shell is then removed, the edges are smoothed and then shell is cemented.
- C. *Cellulose acetate and polycarbonate crown forms*: The crown forms are made of soft, thin and transparent material and are available in different sizes and shapes. The selected crown is filled with a color matching cold cure resin and then seated on the lubricated tooth preparation. After the resin has set, excess resin is removed. In polycarbonate, crown form remains on the tooth preparation as component of provisional restoration, while the cellulose crown is removed before cementation. The crown is polished. The crown is cemented with appropriate cement as per the situation.

## CUSTOMIZED ACRYLIC RESTORATIONS

For making temporary restorations, quick-setting acrylic resin is used. The cold cure methyl methacrylate tooth-colored resin is used to produce temporary restorations. The cured resin material is seated with appropriate cement as per situation.

- a. *Vacuum-formed plastic template (omnivac) technique*: Translucent vacuum-formed template is used to construct anterior or posterior provisional crowns.



## 218 Textbook of Operative Dentistry

A thermal vacuum machine is used to adapt plastic sheet over a stone duplicate die. Tooth colored autopolymerizing resin is filled in the template in area of provisional restoration. After the resin has set, the esthetic contours are adjusted and finalized.

- The provisional restoration is then polished and after that, cemented with an appropriate cement.
- b. *Post crown technique:* Interim crowns for endodontically treated teeth are difficult to make. In the canal, a non-precious readymade metal post is adapted.

**Table 22.1:** Physical properties and uses of IRM (Interim Restorative Materials)

| IRM                         | Composition                                                                                   |                                                                                     | Compressive strength Psi (Mpa) | Tensile strength Psi (Mpa) | Modulus of elasticity (Psi) | Setting time                          | Coeff. of thermal conductivity          | Uses                                                                                       |
|-----------------------------|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|--------------------------------|----------------------------|-----------------------------|---------------------------------------|-----------------------------------------|--------------------------------------------------------------------------------------------|
| Zinc oxide eugenol          | Powder<br>Zinc oxide<br>70% Rosin<br>Zn acetate 30%                                           | Liquid<br>Eugenol<br>100%                                                           | 800 to 4000<br>(6 to 28)       | 300<br>(2.1)               | 0.03                        | 24 hours                              | $3.98 \times 10^{-4} \text{ C/Cm}^{-1}$ | 1. Temporary and intermediate restoration<br>2. Luting agent<br>3. Thermal insulating base |
| Polymer reinforced ZnOE     | Zinc oxide 80%<br>Polymethyl methacrylate 20%                                                 | Eugenol 85%<br>olive oil 15%                                                        | 5400 to 5800<br>(37 to 40)     | 600 (4.1)                  | 0.39                        | 6 to 9 mts                            | —                                       | 1. Temporary and intermediate restoration                                                  |
| EBA-alumina reinforced ZnOE | Zinc oxide 70%<br>alumina 30%                                                                 | Ethoxy benzoic acid 62.5%<br>Eugenol 37.5%                                          | 8700 to 11600<br>(60 to 80)    | 800 (5.8)                  | 0.79                        | 7 to 9 mts                            | —                                       | 1. Intermediate restorations                                                               |
| Zinc Poly-carboxylate       | Zinc oxide 90 to 95%<br>magnesium oxide or Stannic oxide 5 to 10%<br>Stannous fluoride        | Aqueous solution of polyacrylic acid or 40% poly-acrylic acid in water              | 8300 to 14000<br>(57 to 100)   | 900 (6.2)                  | 0.74                        | 7 to 9 mts                            | —                                       | 1. Luting agent<br>2. Thermal insulating base                                              |
| Zinc Silico phosphate       | Silica 35 to 50%<br>Alumina 25 to 30 %<br>Zn oxide 15 to 25%<br>$\text{Ca(OH)}_2$ 1 to 5%     | Phosphoric acid 48 to 58%<br>water 35 to 48%<br>Zinc and Aluminium salts in traces. | 21000 (145)                    | 1100 (7.6)                 | —                           | 3.5 to 4 mts<br>$4.38 \times 10^{-4}$ | —                                       | 1. Intermediate restoration<br>2. Luting cement                                            |
| Resin cement                | Resin matrix; inorganic fillers<br>organosilanes, Photo or Chemical initiators and activators | Methyl meth-acrylate tertiary amine                                                 | 10000 to 25000<br>(70 to 172)  | —                          | 0.31 to 0.46                | 2 to 4 mts                            | $3.25 \times 10^{-4} \text{ C/Cm}^{-1}$ | 1. Intermediate restoration<br>2. Luting cement                                            |

Then a polycarbonate crown is filled with cold cured acrylic resin and placed over the post. After polymerization it is finished and polished. This interim restoration is cemented with a weak adhesive cement.

## TREATMENT RESTORATIONS

They are placed as a sedative restoration, indicated for: (a) Caries control procedures, (b) To provide relief to hypersensitive pulp (pulp with reversible hyperemia), (c) Indirect pulp capping.

- a. *Caries control procedures*: The plaque control, oral prophylaxis procedures and instructions for home care are essential. Before restoring the teeth permanently, temporary restorations are given. This is called 'Temporization'. For temporization, IRM is the best material.
- b. *Hyperactive pulp*: Pulpal pain is due to (a) defective restorations (b) acute caries (c) recurrent caries (d) incomplete tooth fractures. All these conditions require temporization.

The selection of the cement depends upon the timespan for which it has to remain in the teeth. ZnOE cement with cotton fibers is for short intervals, but if lesion is large or the restoration has to last for more than 1 or 2 weeks then resin bonded reinforced ZnOE cement is used as IRM.

- c. *Indirect pulp capping*: Indirect pulp capping is indicated in cases of deep acute caries where carious or mechanical exposure may occur if total caries is to be excavated. In the indirect pulp capping procedure, deep caries is not removed at the time of treatment but treated by placing calcium hydroxide, calcium trioxide, calcium monoxide, Dycal or zinc oxide eugenol over the caries and then sealing the cavity with IRM. If the cavity is not properly sealed, indirect pulp capping procedures do not succeed.

After 12 to 16 weeks, if the following changes are seen on re-entry to the cavity,

1. Re-hardening of the bacteria -free deep caries takes place

2. Reparative dentin formation takes place
3. Pulp returns to the normal state as determined by the tests

Final cavity preparation and restoration are now done.

## Limitations of Temporization

Limitations of the temporary restorations are as follows.

1. *Lack of strength*: Temporary crown may fracture under heavy forces in patients with bruxism or reduced interocclusal clearance.
2. *Poor marginal adaptation*: Marginal leakage takes place in temporary restorations.
3. *Color instability*: If temporary restorations are placed for longer periods discoloration may take place.
4. *Odor emission*: Autopolymerizing resins are porous, so if food accumulation takes place, detectable odor may be present.
5. *Inadequate bonding*: Few cements do not have an adequate relationship with resin which is used for making temporary crown.
6. Time and expenditure is involved in fabrication of interim coverage crowns required for short-term.

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The practice of operative and esthetic dentistry has been revolutionized by the bonding of resins to enamel and dentin. The process by which a restorative material forms a proper union with the tooth surface is known as bonding or adhesion. Bonding or adhesion may be by (a) chemical, (b) physical and/or (c) mechanical means. (a) Chemical means of adhesion involves primary forces, i.e. ionic, covalent and metallic bond. (b) Physical means involve the secondary valence forces such as those occurring at molecular dipoles (van der Waals force), interaction of induced dipoles (dispersion forces), electron bonds (hydrogen bonds) (c) Mechanical means involve the penetration of resin and formation of resin tags.

The bonding techniques allow conservation of tooth structure, improve retention and stabilization, facilitate repairing of restorations and minimize microleakage. The adhesive techniques have widened the horizon of esthetic dentistry as they are able to reinforce the remaining tooth structure by transmitting functional stresses across the bonding interface.

Such adhesive restorations have helped in correcting dimensions and color of teeth; repairing existing composite, amalgam or ceramic restorations; bonding all-ceramic or indirect resin-based restorations, orthodontic brackets, periodontal splints, prefabricated and cast posts, fractured fragments of anterior teeth; sealing pits and fissures. They are used to (a) desensitize dentin and exposed root surfaces; and (b) provide retention for metallic or porcelain fused –to-metal (PFM) crowns.

Bonding to the enamel or dentin requires the use of (a) Etchants, (b) Conditioners, (c) Primers and (d) Bonding Agents.

a. Etchants are chemicals such as phosphoric acid, citric acid or maleic acid which are used for etching, i.e to remove minerals from the surfaces of enamel and dentin by making irregular holes, which increase the surface area. They form tags of restorative material by demineralizing the superficial calcium ions. Etching also increases the surface reactivity.

- b. Conditioners clean the surface. They also activate the calcium ions making them more reactive.
- c. Primers consist of monomers dissolved in water, alcohol or acetone, thus comprising of both the hydrophobic (methacrylate group) as well as the hydrophilic groups (hydroxyl or carboxyl groups). Primers ease the flow of resins.
- d. The Bonding agent comprises of an unfilled resin which also comprises of a hydrophilic and a hydrophobic end. Thus, for proper adhesion to enamel or dentin, the following steps are performed separately.
  - Etching/conditioning
  - Primer application
  - Bonding agent/adhesive application

In newer technique all the three steps have been combined.

## ENAMEL ADHESION

The bonding to enamel should exceed 20 MPa. It is achieved effectively owing to the 'Acid-etching technique' (Buonocore). However, fluoridated enamel is more difficult to etch than non-fluoridated enamel because of its low surface energy. Thus, conditioning or etching is performed to increase surface energy.

Oral prophylaxis procedure is performed thoroughly using non-fluoridated, flavorless, oil less prophylaxis pastes. After washing with water the teeth are isolated to prevent any contamination from saliva or gingival crevicular fluid. Next, acid etchants in the form of liquid or gels are applied for 10 to 15 seconds. Commonly 30 to 40 percent (37%) phosphoric acid is used. If the concentration is greater than 50 percent then mono calcium phosphate monohydrate may get precipitated while at concentrations lower than 30 percent dicalcium phosphate monohydrate is precipitated which interferes with adhesion. Gel etchants are used due to their relative ease and control while placement by a brush or syringe. Deciduous teeth require longer time for etching than permanent teeth due to their aprismatic enamel. Next

etchant is washed away at least for 10 to 15 seconds, the washing time must be doubled for gel etchants. Three different micromorphologic patterns are obtained after etching, which are as follows:

**Type I** In this pattern there is dissolution of enamel prism cores without affecting the periphery.

**Type II** In this pattern the peripheries are dissolved.

**Type III** In this the pattern is less distinct, including areas that resemble type I and II patterns, and areas which bear no resemblance to enamel prism.

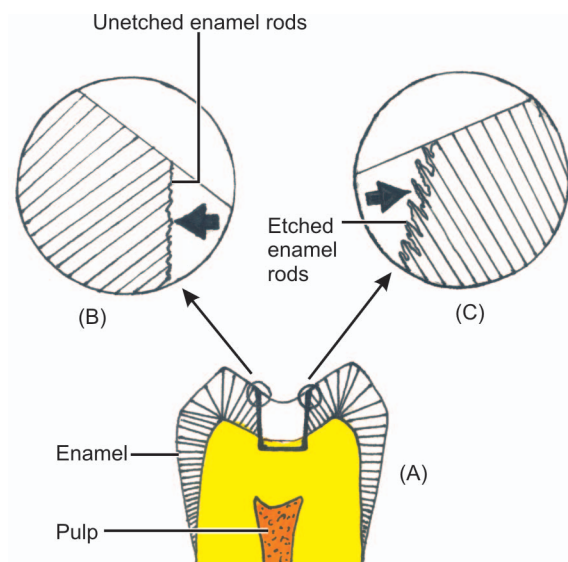
A properly etched surface gives a frosty white appearance on drying. In cases of contamination, the procedure should be repeated. The bonding agent and low viscosity monomers are then applied over the etched enamel surface. The bonding agents due to their low viscosity, rapidly wet and penetrate the clean, dried, conditioned enamel into the microspaces forming resin tags. The resin tags which form between enamel prisms are known as **Macrotags** (Figs 23.1 to 23.3).

The finer network of numerous small tags are formed across the end of each rod where individual hydroxyapatite crystals were dissolved and are known as **Microtags**. The formation of resin micro and macro tags within the enamel surface constitute the fundamental mechanism of enamel-resin adhesion. Basically microtags are more important due to their larger number and greater surface area of contact.

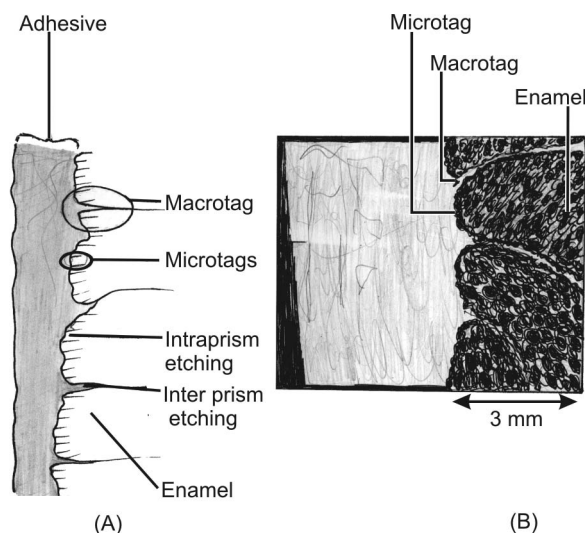
Weaker acids such as 10 percent maleic acid, 2.5 percent nitric acid, citric acid, oxalic acid are also used to etch enamel and dentin simultaneously, but they provide lower shear bond strengths. Recently Nd:YAG and CO<sub>2</sub> LASERS have also been used for etching.

**Table 23.1:** Abbreviations and full forms of commonly used chemicals

|          |                                                |
|----------|------------------------------------------------|
| Bis-GMA  | Bisphenol glyceryl methacrylate                |
| EDTA     | Ethylene diamine tetra-acetic acid             |
| GPDM     | Glycerophosphoric acid dimethacrylate          |
| HEMA     | 2-Hydroxyethyl methacrylate                    |
| 4-META   | 4-Methacryloxyethyl trimellitate anhydride     |
| NPG-GMA  | N-phenylglycine glycidyl methacrylate          |
| PENTA    | Dipentaerythritol penta-acrylate monophosphate |
| PMDM     | Pyromellitic acid diethyl methacrylate         |
| TGDMA/   | Triethylene glycol dimethacrylate              |
| TEGDMA } |                                                |
| UDMA     | Urethane dimethacrylate                        |

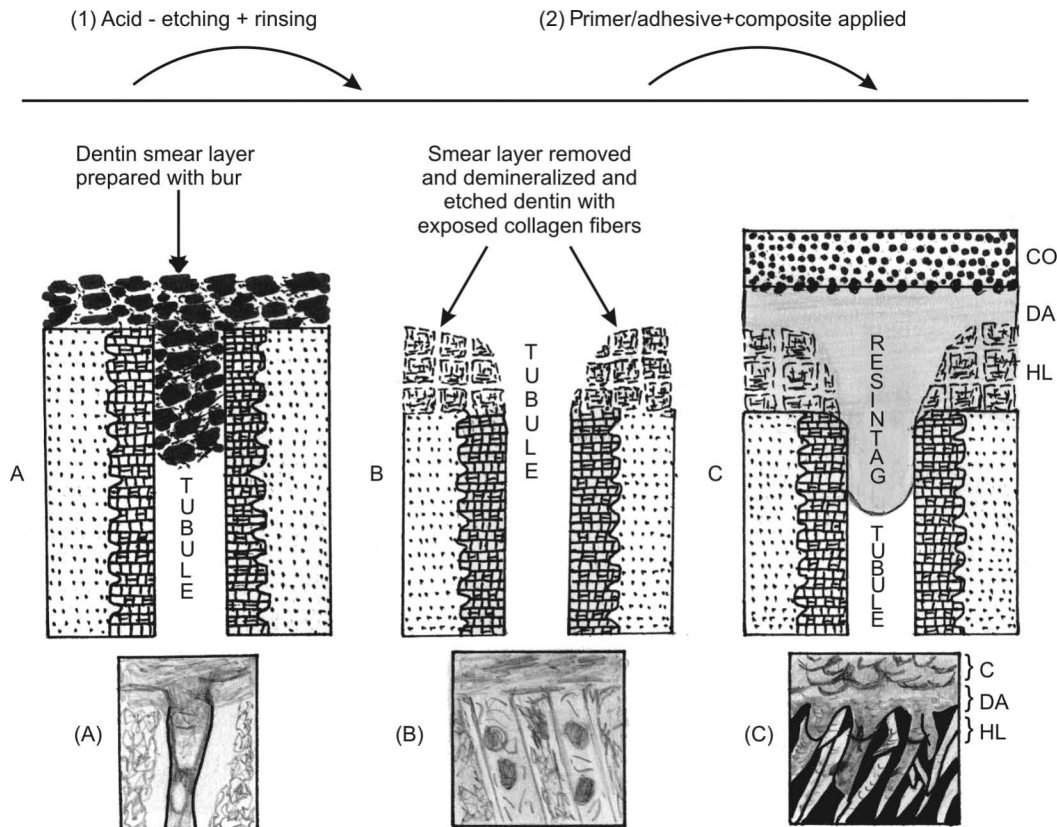


**Fig. 23.1:** (A) Section of tooth showing enamel rods (B) Enamel rods which are unetched provide less effective chemical bonding between tooth surface and composite material. (C) etched surface producing microundercuts which provides more effective bonding



**Fig. 23.2:** Cross-section of micro-mechanical retention of enamel bonding system. (A) Diagrammatic presentation of macrotags and microtags (B) SEM section of enamel bonding agent with enamel showing microtags between macrotags





**Fig. 23.3:** Resin bonding with dentin by 'total etch' technique ABC = are diagrammatic representations. (A) (B) (C) = as seen under electron microscope CO= composite DA= Dentin adhesive HL= Hybrid layer (Hybrid layer is resin dentin inter diffusion zone)

## DENTIN ADHESION

Bonding to dentin is comparatively difficult than enamel as dentin is a complex living tissue comprising more of organic material and fluids.

Dentin in its superficial portion due to being solid has greater bond strength than that in the deeper portions. Natural tubular dentin is comparatively easy to bond than areas of sclerotic dentin. The presence of smear layer affects the bonding. Some believe it to be a protective layer minimizing leakage while others believe it to be an impediment towards adhesion.

However, the retention of smear layer makes dentin impermeable, lowers the effect of pulpal pressure on bond strength as it increases the bond strength despite being in deeper dentin. The demineralization of dentin and removal of smear layer exposes collagen, which provides a framework for micromechanical bonding and

chemical interaction with primers due to their reactive groups. The amino groups may also catalyze the polymerization reactions.

## Conditioning

The conditioning process of dentin is carried out with an objective to alter the dentin as well as the smear layer to promote micromechanical as well as chemical bonding to a dentin adhesive.

The conditioning process may be carried out by chemical, thermal or mechanical means.

Chemical conditioning may be carried out by means of acids or calcium chelators.

## Conditioning by Means of Acids

Various acids such as 37 percent phosphoric acid, nitric acid, maleic acid, oxalic acid, pyruvic acid, hydrochloric acid and citric acid are used.



A combination of 10 percent citric acid with 3 percent ferric chloride causes removal of smear layer and etching. 10 percent citric acid with 20 percent calcium chloride (Clearfil Liner Bond) does not open tubules in a funnel shape and decalcifies dentin to a depth less than that done by phosphoric acid.

Maleic acid (Scotch Bond) removes the smear layer but not the smear plugs. Total etching is done with 37 percent phosphoric acid. Thus, the conditioning procedure not only removes the smear layer but also demineralizes 3 to 7 microns of superficial dentin. This exposes a microporous collagen scaffold which is permeable to resin. Intertubular dentin has its collagen fibers covered with an amorphous layer having microporosities and varying in its thickness. This occurs due to the highly cross-linked and acid-insoluble residual smear layer; collagen getting denatured and collapsing, reducing resin permeability.

The peritubular dentin forms a funnel shaped structure exposing collagen fibrils which are circularly oriented having extra-retentive sides at their tubule wall. Therefore, to enhance wetting and resin-infiltration; and preventing collapse of unsupported collagen a moist dentin surface is preferred after conditioning.

### Chelators

Ethylene diaminetetra acetic acid (EDTA) is the best chelating agent used at a pH of 7.4 for 30 seconds. It removes the smear layer and does not cause any decalcification or funnel shaped changes in dentin. In cases of self-etching/self-priming agents, the demineralized smear layer is retained in the bonding. Since 21 percent of the smear unit behaves as water filled channel, the slightly acidic self-etchants enlarge these channels and enhance resin permeability.

*Thermal conditioning:* Encompasses the use of LASER to condition dentin.

### Priming

Primers consist of monomers especially HEMA (2 Hydroxyethyl methacrylate) and 4-META (4-Methacryloxyethyl trimellitate anhydride) dissolved in acetone or ethanol. Thus, they have both hydrophilic as well as hydrophobic ends which have affinity for the exposed collagen and resin respectively. The acetone or ethanol on volatilization displaces water from dentin as well as collagen fibrils. Thus, the dentin is neither too dry so as

to cause collapsing of collagen nor too wet so as to emulsify the polymerization of resin. Hence, resin can penetrate easily. For obtaining bond strengths that are optimum the primer should be applied in several coats so that it forms a uniform surface coverage (Table 23.1).

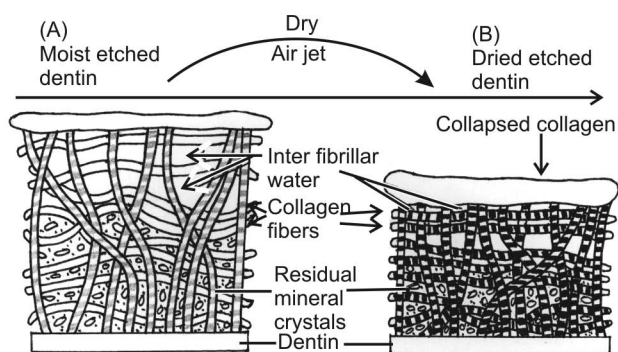
### Adhesion Resins/ Dentin Bonding Agents

The adhesive resin is a low viscosity, semi filled or unfilled resin which flows easily and matches the composite resin. The layer of adhesive resin should not be dried by air stream as this results in an uneven surface which is incapable of absorbing stresses of polymerization shrinkage. The penetration of adhesive resins into the microporous collagen scaffold of the inter-tubular dentin is known as the intertubular penetration. Polymerization and co-polymerization with the adhesive parts of the primer give rise to an intermingled layer of collagen and resin known as the '*Hybrid layer*' or '*Resin reinforced layer*'. The remainder of the adhesive resins give rise to the intratubular penetration or the formation of resin tags upto a limited depth of 10 to 20 microns. It is only at this point that the tags are attached to the peritubular dentin.

The presence of dentinal fluid under pulpal pressure, and sclerotic dentin inhibit resin infiltration, whereas porosity between collagen fibrils aids it. Both inter and intratubular permeabilities are essential for optimum bond strength and sealing properties, failure of which can lead to microleakage in such microspaces called as *Nanoleakage*. A proper bonding seals all dentinal tubules, reduces pulpal irritation and protects the pulp. In latest systems, resins can penetrate walls of branches of lateral tubule branches, form hybrid layer and submicron resin tags. This is termed '*lateral tubule hybridization*'.

Bond strength in superficial dentin is due to intertubular penetration while in deep dentin it is due to intratubular penetration.

Adhesive resins which are used may be cured chemically or by means of light. If a light cured adhesive resin is used it is cured separately so that the polymerized hybrid layer would be better able to withstand the polymerization shrinkage of the composite resin. The unpolymerized methacrylate double bonds, present in the oxygen inhibited layer (15 microns) formed on surface of adhesive resin, co-polymerizes with the composite resin (Fig. 23.4).



**Fig. 23.4:** Due to air drying collagen fibers collapse and prevent resin monomers from penetrating dentin (A) Moist etched dentin with more interfibrillar water which help deeper penetration of monomer into dentin (B) Dried etched dentin with very less interfibrillar water which prevent deeper penetration of monomer

## MECHANISM OF DENTIN BONDING (ADHESIVE SYSTEMS)

The dentin bonding agents (DBA) should have a hydrophilic end which readily wets and penetrates into the porosities of dentin, reacting with their organic or inorganic components; and a hydrophobic end which bonds to the composite resin. Thus, the adhesive molecule has a bifunctional structure:



Where M → represents the double bond of methacrylate which copolymerizes with composite resin.

R → represents the spacer which makes molecules large so that the methacrylate bonds are located for optimum reaction.

T → represents adhesion to tooth dentin structure either to organic or inorganic part. T either bonds to inorganic or organic portion of dentin.

Bonding to organic part of dentin involves interacting with Amino (-NH), Hydroxyl (-OH), Carboxylate (-COOH), Amide (-CONH) groups present in dentinal collagen. Dentin bonding agents have isocyanates, aldehydes, carboxylic acid anhydrides and carboxylic acid chlorides which remove hydrogen from the above groups and combine chemically. Example of adhesives that bond to organic part include Gluma (aldehyde based)

Bonding to inorganic part of dentin involves ionic interaction among the negatively charged group on T and the positively charged  $\text{Ca}^{2+}$  ions. Group T can be phosphates, amino acids and amino alcohols, or dicarboxylates. The phosphate bonding systems are generally used. Examples of adhesive that bond to inorganic part include -Clearfil, Scotchbond, Bond lite, Prisma Universal Bond, etc.

On the basis of their evolution, the bonding agents have been divided into 'Generations'.

## BONDING GENERATIONS

### First Generation Dentin Bonding Agents (DBA)

Bonding was achieved through chelation of the bonding agent to the calcium component. In late 1970s NPG-GMA (N-phenyl-glycine-glycidyl methacrylate) marketed commercially as Cervident (SS White) was used as a surface active comonomer. Bonding was pitifully low, hence was useful only for class III and class IV cavities. Since they could chelate with calcium ions of the tooth substance they formed stronger bonds with enamel than dentin. Bond to dentin is 2 MPa (Tables 23.2 and 23.3)

### Second Generation Dentin Bonding Agents

In early 1978 a phosphate -ester material { phenyl -P [2-Methacryloxy ethyl phenyl hydrogen phosphate] and HEMA (2-Hydroxyethyl methacrylate) in ethanol} which was marketed commercially as Clearfil (Kuraray, Japan 1978) emerged as the second generation DBA. The negatively charged phosphate groups in the resin reacted with the positively charged calcium in the smear layer. Other examples include- Scotchbond (3M), Bondlite (Kerr), Prisma Universal Bonding Agent. (Johnson and Johnson). These products attempted to use the smear layer as a bonding substrate. The *smear layer* because of its comparatively loose attachment to dentin surface was the weakest link in this system. Smear layer debris was present on both the sides when failed bond was examined (Tables 23.2 and 23.3).

## DISADVANTAGES OF FIRST AND SECOND GENERATION DBA

1. The *in vitro* bond strengths (2 to 3 MPa) are inadequate to overcome stresses during polymerization shrinkage. Hence, mechanical retention form in cavity preparation was still required.

Table 23.2: Generations of bonding (adhesives)

| <i>Bonding (Adhesive) generation</i> | <i>Characteristics</i>                                                                                                                                                                                                                                            | <i>Bond strength to dentin (in MPa)</i> | <i>Components</i> | <i>Examples</i>                                                                                  |
|--------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|-------------------|--------------------------------------------------------------------------------------------------|
| 1st                                  | Very weak bond to dentin                                                                                                                                                                                                                                          | 2                                       | 1                 | Cervident<br>Cosmic Bond                                                                         |
| 2nd                                  | Weak adhesives requiring retentive preps<br>Prone to water degradation                                                                                                                                                                                            | 2–8                                     | 2                 | Bond Lite<br>Scotchbond<br>Dentin Adhesit                                                        |
| 3rd                                  | 2 component primer and adhesive system. Bonding to metals. Reduced sensitivity                                                                                                                                                                                    | 8–15                                    | 2–3               | Prisma Universal<br>Bond, Scotchbond<br>Tenure, Gluma<br>X-R Bond                                |
| 4th                                  | Hybridization, total etch<br>Little sensitivity                                                                                                                                                                                                                   | 17–25                                   | 2–5               | All Bond II Pro<br>ProBond<br>Scotchbond MP<br>Tenure<br>Bond it<br>Syntac                       |
| 5th                                  | Single component<br>Moist bonding,<br>hybridization Bond Prime &<br>No mixing<br>Little sensitivity                                                                                                                                                               | 3–25                                    | 1                 | Gluma Comfort<br>Bond NT. Single<br>Bond. Excite<br>One Step<br>Bond 1                           |
| 6th                                  | Multi component<br>Multi step<br>Self-etching (enamel ?)<br>Self-priming<br>Hybridization<br>Very little sensitivity                                                                                                                                              | 18–23                                   | 2–3               | Prompt- L-Pop<br>SE Bond,<br>Liner Bond II                                                       |
| 7th                                  | Single component<br>Desensitizing<br>Self-etching<br>Self-priming<br>Disinfecting<br>No mixing<br>Moisture independent<br>Bonds to metal<br>No or temporary very little sensitivity<br>Truly one step bonding agent for use with direct and indirect restorations | 18–25                                   | 1                 | iBOND                                                                                            |
| 8th                                  | Stronger Bonds                                                                                                                                                                                                                                                    | 38<br>39<br>47                          |                   | Single Bond (3M ESPE)<br>Opti bond solo plus (3M ESPE)<br>Adper single bond 2 Adhesive (3M ESPE) |

## 226 Textbook of Operative Dentistry

2. Since these resins lacked hydrophilic groups, they did not wet dentin properly.
3. The interface between dentin and resin was unstable due to the insufficient knowledge about the smear layer.

### Third Generation Dentin Bonding Agents

In late 1980s the third generation DBA two component primer/adhesive systems were introduced. This was the concept of conditioning and priming before their application. Sometimes conditioning and priming occurred in a single step when 'self-etching' 'primers' were used. The need for retention form in cavity preparation was reduced. The erosion, abrasion and abfraction lesions were treatable with minimal tooth preparation. Although the bond strengths were higher (8 to 15 MPa) and microleakage was reduced. Higher bond strength and reduced microleakage decreased with time and did not last long. (Tables 23.2 and 23.3) The desired bond strength is above 17 MPa. Examples include the following-Clearfil New Bond (HEMA and 10-MDP), Scotchbond 2 (3M)(2.5% Maleic acid, 55% HEMA, and a trace of methacrylic acid), Gluma (Bayer) (EDTA, 5% Glutaraldehyde and 35% HEMA in water) EDTA-Ethylene diamine tetra-acetic acid. 10-MDP=10 Methacryloyloxy decyl dihydrogenphosphate.

### Fourth Generation Dentin Bonding Agents

Fourth generation bonding agents improved dentistry. The high bond strength to dentin (17 to 25 MPa) and decreased postoperative sensitivity in posterior occlusal restorations, encouraged the switchover from amalgam to direct posterior composite fillings. The fourth "generation" is characterized by the process of hybridization at the interface of the dentin and the composite. *Hybridization* is the replacement of the hydroxyapatite and the water in the surface dentin by resin. This resin, in combination with the remaining collagen fibers, constitutes the hybrid layer. Hybridization involves both the dentinal tubules and the intratubular dentin which has greatly improved bond strength to dentin. It involves multibottle and multiple steps.

The fourth generation adhesives consist of i) an acid etching gel to remove smear layer ii) primers –reactive hydrophilic monomers in ethanol, acetone or water iii) an unfilled or filled resin fluid bonding agent. Thus, the resin diffuses and impregnates the partially decalcified

dentin and polymerises to form a 'hybrid layer' (1991, Nakabayashi) (Tables 23.2 and 23.3). The following examples comprise the fourth generation DBA's-

1. All bond-2 (Bisco)
  - i. 35% phosphoric acid
  - ii. 2% NTG GMA (N-Tolyglycine-glycidyl methacrylate) and 16% BPDM (biphenyl dimethacrylate) in ethanol or acetone
  - iii. Bis-GMA (Bisphenol glycidyl methacrylate)+ HEMA (2-Hydroxy ethyl methacrylate)
2. Scotch bond multipurpose (3M)
  - i. 10% maleic acid
  - ii. Aqueous solution of HEMA (2- Hydroxy ethyl methacrylate) and poly alkenoate copolymers,
  - iii. Bis-GMA (Bisphenol glycidyl methacrylate) containing HEMA
3. Optibond FL (Kerr)
4. Clearfil liner bond 2 (Kuraray).

### Fifth Generation Dentin Bonding Agents

Fifth generation dental adhesives adhere well to enamel, dentin, ceramics, and metal. They have a single component, single bottle. There is no mixing, and thus, no possibility for error. They are suitable for all dental procedures (except in conjunction with self-curing resin cements and self-curing composites).

Fifth "generation" bonding agents are easy to use and predictable. They are the very popular adhesives. There is little technique sensitivity in a material that is applied directly to the prepared tooth surface. Postoperative sensitivity has been reduced appreciably (Tables 23.2 to 23.4).

These combine the priming and bonding steps but etching is performed separately. Thus, it is more user-friendly as application time and number of steps is reduced. Bond strengths are almost equal to that of fourth generation adhesives, i.e. 20 to 25 MPa. The following are some of the fifth generation systems in the market.

1. Prime and Bond (Dentsply): [containing PENTA (Dipenta erythritol penta-acrylate monophosphate), TEGDMA (Triethylene glycol dimethacrylate) and an elastomeric UDMA (Urethane di methacrylate) resin in acetone.]
2. Prime and Bond 2.1[with cetylamine fluorides]
3. OptiBond Solo (Kerr) [consists of HEMA (2-Hydroxyethyl methacrylate), GPDM (Glycero

**Table 23.3:** Advantages and disadvantages of popular bonding agents

| <i>Bonding agents</i>                                                                             | <i>Advantages</i>                                                                                                                                                                                                                                                      | <i>Disadvantages</i>                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Self-etching primer (Clearfil SE Bond)                                                         | <ol style="list-style-type: none"> <li>1. No rinsing, quick application.</li> <li>2. Less postoperative sensitivity in comparison to total-etch adhesives.</li> <li>3. Bonds very well to dentin etched with phosphoric acid.</li> </ol>                               | <ol style="list-style-type: none"> <li>1. Enamel microleakage may occur because of deficient enamel etch.</li> <li>2. Slight degradation of the hybrid layer.</li> </ol>                                                                                                                                                                                                                                                                                        |
| 2. Self-etching all-in-one adhesive (Prompt L-Pop)                                                | <ol style="list-style-type: none"> <li>1. No rinsing, very quick application</li> <li>2. Results in enamel etch pattern similar to that of phosphoric acid</li> <li>3. No bottles, no cross-contamination</li> </ol>                                                   | <ol style="list-style-type: none"> <li>1. Wide range of bond strength values.</li> <li>2. Bonding is better with compomers in comparison to composites.</li> <li>3. Multiple coats are needed for effective bonding to dentin</li> </ol>                                                                                                                                                                                                                        |
| 3. Total etch multibottle adhesives (All-Bond 2, Scotch bond multi-purpose, optibond FL)          | <ol style="list-style-type: none"> <li>1. Research showed their use on different substrates.</li> <li>2. Highest dentin bond strength among all the adhesives</li> <li>3. Generally contain a dual-cure option for indirect restorations and bonded amalgam</li> </ol> | <ol style="list-style-type: none"> <li>1. Multiple bottles make their use complicated</li> <li>2. Possibility of running out of primer A before primer B (or vice versa)</li> <li>3. Because primer and adhesive resin are dispensed into the same plastic container, their sequential application may be changed.</li> </ol>                                                                                                                                   |
| 4. Total etch one-bottle adhesive (Excite, One step, Opti Bond Solo Plus, P&I, Prime and Bond NT) | <ol style="list-style-type: none"> <li>1. Research showed their use on enamel and dentin</li> <li>2. Clinically, very positive results</li> <li>3. The one-bottle concept makes them extremely user friendly</li> </ol>                                                | <ol style="list-style-type: none"> <li>1. Lower bond strength than multi-bottle adhesives.</li> <li>2. Acetone-based adhesives may lose their efficacy with constant utilization.</li> <li>3. Acetone-based adhesives may need more coats than those recommended by the manufacturer.</li> <li>4. Ethanol-based adhesives may pool easily around the preparation margin</li> <li>5. Most one-bottle adhesives cannot be used as dual cure materials.</li> </ol> |

**Table 23.4:** Comparison of steps with time (in seconds) required by various products to bond in various generations

| <i>Generations and product Steps Etch</i> | <i>Time Wash</i>          | <i>required Dry</i> | <i>in Dispense</i> | <i>seconds Apply</i> | <i>for Dry</i> | <i>each Light Cure</i> | <i>step</i> |
|-------------------------------------------|---------------------------|---------------------|--------------------|----------------------|----------------|------------------------|-------------|
| <i>5th Generation</i>                     |                           |                     |                    |                      |                |                        |             |
| 1. Optibond solo plus                     | 15                        | 15                  | 3                  | Yes                  | 15             | 3                      | 20          |
| 2. Prime & Bond NT                        | 15                        | 15                  | 3                  | Yes                  | 20             | 3                      | 10          |
| 3. Single Bond                            | 15                        | 15                  | 3                  | Yes                  | 2 coats        | 5                      | 10          |
| <i>6th Generation</i>                     |                           |                     |                    |                      |                |                        |             |
| 4. Clearfill SE Bond                      | Dispense 20               | Apply               | 3                  | Yes                  | 15             | 3                      | 10          |
| 5. Prompt-L-Pop                           | squeeze                   | squeeze             | mix                | -                    | 15             | 3                      | 10          |
| <i>7th Generation</i>                     |                           |                     |                    |                      |                |                        |             |
| 6. i Bond                                 | Apply 3                   | Wait 30             | 3                  | -                    | -              | -                      | 15 to 20    |
|                                           | Conse-<br>cutive<br>coats |                     |                    |                      |                |                        |             |



## 228 Textbook of Operative Dentistry

phosphoric acid dimethacrylate) and Bis-GMA (Bisphenol glycidyl methacrylate) in an ethanol or water system]

4. Single Bond (3M)
5. PQ 1. (Ultradent)

### Sixth Generation Dentin Bonding Agents

Since 2000 these single bottle adhesives are available which combine etching, priming and bonding in a single solution and as a single step. Etching as a separate step is eliminated. This facilitates manipulation. Since they consist of an acidic solution they cannot be stored and have to be refreshed. Their pH is inadequate to etch enamel hence bond to enamel is weaker as compared to dentin. Bond to dentin is 18 to 23 MPa. Examples are Prompt-L-pop and clearfill SE bond (Tables 23.2 to 23.4).

### Seventh Generation Dentin Bonding Agents (Adhesive systems)

Freedman G and Leinfelder recently described a new, simplified adhesive system which is the first representative of the seventh generation. The seventh generation simplified the multiple of sixth generation materials into a single component, single bottle system. It has disinfecting and desensitizing properties also. Bond to dentin is 18 to 25 MPa (Tables 23.2 to 23.4).

Both the sixth and seventh generation adhesives are self-etching, self-priming adhesives which are minimum technique sensitive. The seventh generation DBA have very little or no postoperative sensitivity. Example is 'i Bond'.

Stephen H. Wei and Franklin R. Tay concluded that self-etch adhesive when compared to the adhesive systems that use phosphoric acid conditioning have the following advantages:

1. Comparable adhesion and bond strengths to enamel and dentin.
2. No postoperative sensitivity
3. Much faster and simpler technique.
4. It is much less technique sensitive as much less number of steps are involved for the self-etch system.

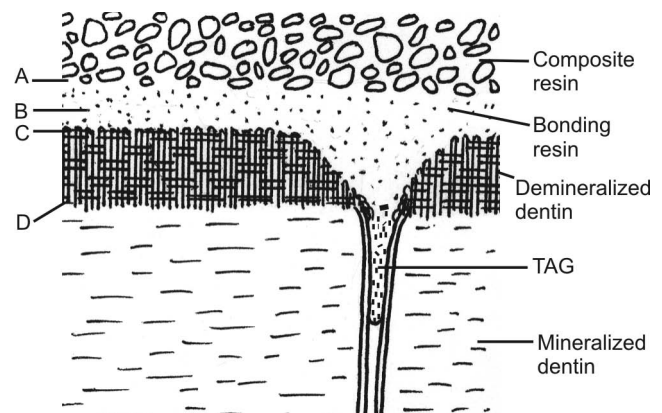
### Eighth Generation

In this there is stable nanofiller that will not settle out of dispersion. It is suitable for direct and indirect restorations. Single Bond (3M ESPE), has bond strength of 38 MPa and Optic Bond Solo Plus (3M ESPE) has

with dentin bond strength of 39 MPa. Adper single bond 2 adhesive (3M ESPE) for direct and indirect restorations has bond strength of 47 MPa.

### ROLE OF WATER IN THE BONDING PROCESS

When dentin is etched with acid, a demineralized surface covered with water is left behind. Areas from where minerals are removed are filled with water. This water acts as a plasticiser for collagen, keeping it in an expanded soft state. Thus, spaces for resin infiltration are also preserved. Air drying evaporates the water leaving collapsed collagen. For acetone/ethanol based water free dentin bonding systems, the etched air syringe dried dentin must be rewetted before applying the adhesive (Fig. 23.5).



**Fig. 23.5 :** Four positions of failure at the resin adhesion tooth interface

- A. Between composite resin and bonding resin
- B. Within bonding resin
- C. Between bonding resin and demineralized dentin
- D. Between the demineralized dentin and mineralized dentin

It is due to surface tension forces and also the secondary forces which become active on closer association of the collagen fibrils so that collagen becomes stiffer. On rewetting, the collagen network assumes its original volume. The moist dentin, thus, consists of an expanded collagen network and open interfibrillar spaces. Efficient bonding involves elimination of some water from dentin and its replacement by monomers during priming.

The wet bonding technique uses primers consisting of hydrophilic resin monomers dissolved in water miscible organic solvents like ethanol and acetone. When

Primer is applied to moist dentin, water diffuses from it to the organic solvent, while the solvent diffuses along with the polymerizable polymers into the demineralized dentinal matrix and tubules. Since water is lost gradually, the wet bonding technic has a better bonding ability than dry bonding.

If the hydrophilic monomer fails to remove water completely from the dentin, over-wetting phenomenon results. In this the solubility of monomers is lowered, as the excess moisture lowers the concentration of organic solvents in the primer. Dentinal tubules are more prone to show this phenomenon than the intertubular dentin due to their high water content. Monomer is present as globules over the water layer. The dentin surface may appear 'blister like' with water being trapped beneath the resin layer.

In dry bonding technique, if water-free, acetone-based primers are used, they form 'Hybridoid regions,' due to their ineffective penetration into the exposed collagen network because of the absence of water. Thus, it is necessary that a correct amount of water be present for good and effective bonding.

Low bond strength results from air dried dentin due to deficient penetration of the adhesive into the tubules and intertubular dentin. Clinically assessment of correct amount of water left in dentin is difficult. Hence, air drying by air-water syringe should not be done. The excess water after rinsing with etching gel should be removed with a damp cotton pellet or a disposable brush without adversely affecting the bond strength.

## BONDING AS RELATED TO VARIOUS MATERIALS

### Bonding Glass Ionomer to tooth structure

Glass ionomer cements (GIC) bond successfully to enamel, dentin as well as reactive polar substrates such as base metals. They do not require surface roughening or acid etching procedures as they bond by chemical means rather than by micromechanical means. Highly ionic and hydrophilic GIC contacts with water due to the multiple carboxyl groups and forms hydrogen bonds with the tooth substrate. Water is either displaced or incorporated into the GIC. Thus, a permanent adhesion and resistance to water degradation is obtained. With the setting of GIC the hydrogen bonds are replaced by ionic bonds. These ionic polar bonds can be re-established than the covalent chemical bonds which

cannot be reformed, if broken. The polyacrylate ions enter the molecular structure of hydroxyapatite, displacing and replacing one calcium and phosphate ion. Thus, they give rise to an intermediate layer of calcium and aluminium phosphate and polyacrylate at the cement - apatite interface. Hence, bonding to enamel will be greater than dentin due to its increased hydroxyapatite content.

### Bonding Composites to Glass Ionomer Cements

The '*Bilayered*' or '*Sandwich technique*' is the term used to describe etching of enamel and GIC before placement of composite resin. Here, GIC acts as dentin. The GIC is required to set completely (atleast 20 minutes) prior to etching or the unreacted particles may dissolve and weaken it. Thirty-seven percent phosphoric acid is used to etch for 15 to 20 seconds. Etching provides mechanical retention to the resin. Bond strengths at the GIC composite interface depends upon (a) the type of GIC (high strength are better), (b) the rate of setting (faster setting are preferred), and the (c) amount of GIC (adequate bulk reduces stresses due to polymerization shrinkage)

### Bonding Composites to Porcelain

The bonding occurs by means of mechanical interlocking and chemical union, e.g. cementing porcelain inlays or onlays on tooth using a resin based cement. The fitting surface of porcelain is etched by means of dilute hydrofluoric acid or sand blasted (alumina) to increase surface roughness and hence mechanical retention. The concentration of the etchant, and the type of porcelain determine the time for etching. The mechanical adhesion is further improved by minimizing the gap between the bonding medium and porcelain, by the use of a low viscosity resin which penetrates into the pores by capillary action.

The chemical adhesion depends upon the treatment of etched surface by means of a silane coupling agent, which improves wettability and promotes mechanical interlocking.

### Bonding Amalgam to Resin

The superiority of bonded amalgam over conventional amalgam is still undecided. However, bonding is advantageous as it- i) reduces microleakage ii) prevents recurrent caries iii) increases fracture resistance iv) increases retention without incorporating any retentive

## 230 Textbook of Operative Dentistry

grooves, pins, or dovetails. The bonding agents for amalgam should have dual characteristics, to achieve optimal wetting, since amalgam is hydrophobic while enamel is hydrophilic. The commonly used comonomers are 4-META (4-Methacryloxyethyl trimellitate anhydride) and 10-MDP (10-Methacryloyloxy decyl dihydrogenphosphate). Amalgam interlocks micro-mechanically with the resin during condensation. The bond between resin and tooth is quite strong. Failures usually occur at the bonding agent and amalgam interface.

### Clinical Performance of Adhesives

The success or failure of adhesives depends upon several factors described as follows:

- i. *Size and shape of lesion:* Small sized cervical lesions show less adhesion as compared to deeper, wedge shaped lesions.
- ii. *Arch type:* Adhesion is better in cases of maxillary arch than mandibular arch due to the lesser chances of moisture contamination.
- iii. *Substrate:* Variations in the substrate affect the clinical performance of adhesive systems in a major way.
- iv. *Age:* With increasing age dentin gets sclerosed and thus adhesives show a greater failure rate. Apart from old age, the age of lesion and the time period for which dentin was exposed also play an important role in retention.
- v. *Tooth flexure:* Increased tooth flexure may be a factor for failure of restorations especially at cervical margins. This is due to the generation of compressive and tensile forces by heavy centric occlusal and eccentric forces which debond the resin restoration.
- vi. *Dentin wetness:* Bonding agents with good wettability help in spreading of monomer on dentin. Also the permeability of demineralized dentin ensures successful bonding.
- vii. *Elastic bonding concept:* The intervening adhesive resin should be adequately elastic to prevent debonding at tooth-composite interface by the polymerization shrinkage stresses. Thus, adequate thickness of GIC liner or unfilled or semifilled bonding resins should be used.
- viii. *Material factors:* For successful bonding a thorough knowledge of the chemistry of the

materials should be known. Hydrophobic bonding agents fail to bond properly. Insufficient rinsing of conditioner due to improper instructions for use will also prevent adequate bond formation.

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# *Introduction to Composite and Other Direct Tooth-Colored Restorations*

## **DEVELOPMENT OF TOOTH-COLORED RESTORATIVE MATERIALS**

The modern history of tooth-colored restorative materials was started with silicate cement which was introduced by Fletcher in the year 1878 in England. Its use was further promoted by Steenback and Ashor in 1903.

An interpretation of esthetics is primarily governed by an individual's perception and varies from person to person. What is pleasing for one patient may not be acceptable to another. Therefore, the responsibility lies with the clinician to present all restorative alternatives to the patient and help him/her to make a final decision about the choice of restorative material. Many patients want their teeth to have a natural look, even in those areas of dentition which normally are not visible. The materials that have been used esthetically in all types of cavity preparations include silicate cement, fused porcelain, glass ionomer, acrylic resins and composites. Out of these, composites have largely replaced all other types of tooth-colored restorative materials used for conservative esthetic restorations. The life span and esthetics of such restorations depend on operator's skill, choice of restorative material and patient's cooperation in practising meticulous oral hygiene maintenance procedures.

Self-curing acrylic resins were developed in 1930 in Germany, but they became popular in Dentistry in late 1940s. It was used as esthetic veneer on the facial surface of metal restorations and as facings in crowns and bridges. It had poor physical properties and was successful only in protected areas. In an attempt to improve the physical characteristics of unfilled acrylic resins, R Bowen, in 1962 developed a polymeric dental restorative material reinforced with silica particles as fillers. Such materials were called 'composites'. These

materials have excellent physical properties comparable to that of natural tooth tissue and are used almost everywhere as direct esthetic restorative materials. As such, they have completely replaced silicates and acrylic resins to become the most popular tooth-colored restoration material. When compared with metallic restorations, composite materials have better esthetics, marginal integrity, low thermal conductivity and low toxicity. In continuation with the undergoing research work, glass ionomers were developed by Wilson and Kent in 1972. These materials have physical properties similar to silicates but were less soluble than silicate cements. They are excellent materials for restorations of root surface caries because of adhesion to dentin and anticariogenic effect.

The dental research workers were continuously searching for an ideal esthetic material. The treatment planning and selection of restorative material affects the patient's appearance. In the anterior restoration, esthetics is directly related to color and translucency of the restorative materials. For posterior teeth, indirect inlays/onlays and indirect ceramic restorations have been described. These materials have advantage over gold and amalgam, of having superior esthetics.

## **SILICATE CEMENT**

Till 1965, it was used extensively to restore the anterior teeth. Silicate cement powder is composed of acid-soluble glasses and phosphoric acid, buffering agents and water. It has been recommended for small cavities in the anterior tooth. Cavity preparations for silicate cement should be of the conventional type. Poor strength, irritation to pulp tissue and brittleness are the disadvantages of silicate. Therefore, its use has been almost discontinued.



Previously, they were indicated for restorations of anterior teeth in patients with high caries index in the areas which are not subjected to masticatory forces. Now-a-days silicate cements have been replaced completely by composites, as restorative materials.

## UNFILLED ACRYLIC RESINS

Self curing or chemically curing unfilled acrylic resins for restoration of anterior teeth were introduced into dentistry in late 1940s. These materials are mostly available as powder and liquid systems. The tooth-colored powder is composed of fine grindings of polymethyl methacrylate polymer and the liquid is basically methyl methacrylate monomer. The powder also contains benzyl peroxide as initiator, while the liquid contains hydroquinone as an inhibitor and a tertiary amine as activator.

### Advantages

The material has no inherent advantages for use as direct esthetic restorative material except the tooth color matching ability, ease of manipulation and it being cheaper in cost.

### Disadvantages

These early materials were disappointing because of certain inherent disadvantages (Fig. 24.1) as follows:

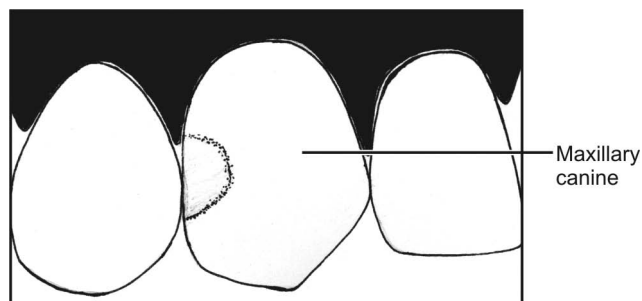
1. Poor activator system.
2. High polymerization shrinkage.
3. High coefficient of thermal expansion (CTE).
4. Lack of abrasions or wear resistance.
5. Poor marginal seal leading to microleakage.
6. Irritation and injury to pulp.
7. Color changes.
8. Poor strength and hardness.
9. Dimensional instability.
10. No bonding to tooth structure.

### Cavity Preparation

Usually, conventional or beveled conventional (as described under section of composites) cavity preparation is required for acrylic resins. Adequate internal retention should be provided for the material.

### Restoration

In thick consistency monomer-polymer mixture is filled into the cavity in small increments. Each new increment



**Fig. 24.1:** Acrylic resin restoration on distal surface of maxillary canine, marginal discoloration exhibited after several years of restoration

is added after the previous one has polymerized so as to compensate for polymerization shrinkage. The cavity is also acid etched before inserting the resin mixture to aid in retention and to reduce the marginal microleakage.

### Indications

Now-a-days acrylic restorations are rarely used. As a restoration acrylic resin was used mostly in protected areas where temperature change, abrasion and masticatory stresses are minimal. Today, they are mainly used for making temporary restorations.

## COMPOSITE RESINS

As a direct tooth-colored restorative material, acrylic resins have been completely replaced by composites. The term *composite material* refers to a three-dimensional combination of at least two chemically different materials with a distinct interface separating the components. The classical dental composite is the mixture of ceramic particles mixed with a polymer matrix.

In search of ideal tooth-colored restorative material, attempts were being made to improve the properties of unfilled acrylic resins. This search resulted in the development of composites or resin-based composites by R Bowen in 1964. Composites are presently the most popular tooth-colored materials which can be used almost anywhere in the dentition for any kind of restoration. These materials consist of a continuous polymeric or resin matrix (matrix phase or reinforced phase) in which an inorganic filler is dispersed (dispersed phase or interrupted phase). This inorganic

## 234 Textbook of Operative Dentistry

filler is responsible for significantly enhanced physical properties of composite as it increases the strength and decreases the co-efficient of liner expansion bringing it nearer to the tooth structure. The filler which is usually silica, also provides enamel-like translucency to the material by scattering and transmission of light. The matrix base consists of polymeric difunctional monomer like BIS-GMA or UDMA which is diluted with TEGDMA to decrease its viscosity. Interfacial bonding between the matrix phase and the filler phase is provided by coating the filler particles with silane coupling agents. This bonding increases the strength of the composite and reduces its solubility. Such coupling agents work best with silica particles. Therefore, all composites have been based on silica containing fillers. Lithium, aluminum, barium and zinc ions are added to modify the filler compositions. Mostly the silica used is in non-crystalline or glass form which is easy to finish and polish. The size of the filler particles and their relative percentage controls the properties of composites. Composite can also be classified on the basis of (a) Matrix compositions (like BIS-GMA or UDMA) and (b) Polymerization method (like self-curing, ultraviolet light curing, visible light curing, dual curing, or staged curing). Composite polymerize by addition reaction that is initiated by free radicals generated by chemical activation or external energy (heat/light).

### PROPERTIES OF COMPOSITE RESTORATIVE MATERIALS

1. *Linear co-efficient of thermal expansion (LCTE):* LCTE of improved composite is approximately three times of tooth structure. Bonding the composite to etched surface reduces the potential negative effects due to the difference between LCTE of tooth and materials.
2. *Water absorption:* Composite with higher filler content exhibits lower water absorption and, therefore, exhibits better properties, than composite with lower filler content.
3. *Wear resistance:* Wear resistance is a property of filler particles depending on their size, shape and content. The location of restorations in dental arch and occlusal contact relationship also affect the potential wear of these materials. Wear resistance of composite materials is generally good.
4. *Surface texture:* The size and composition of filler particles determine the smoothness of the surface of a restoration. Microfill composites offer the smoothest restorative surface. This property is more significant if the restoration is in close approximation to gingival tissues.
5. *Radiopacity:* Most composites contain radiopaque fillers like barium glass to make the restoration sufficiently radiopaque in order to detect the radiolucent image of recurrent caries around or under the restorations, when seen on a radiograph.
6. *Modulus of elasticity:* Rigidity or stiffness of a material is directly proportional to its modulus of elasticity. Microfill composites have greater flexibility than hybrid composite. In restoring Class V lesions or defect composites with lower modulus of elasticity (less rigid and more flexible) should be used, if the tooth is subjected to heavy occlusal forces. In such cases, stress concentration occurs in cervical area. More flexible composite material protect the bonding interface.
7. *Solubility:* Composite materials do not show any clinically significant solubility in oral fluids.
8. *Polymerization shrinkage:* Composite materials shrink while curing. This can lead to failure of interfacial bonding. It is usually more significant when the cavity preparation extends up to the root surface causing a 'V' shaped gap formation between the composite and root surface due to polymerization shrinkage. The configuration factor (C-factor) is the ratio of bonded surface of the restoration to the unbounded surfaces. The higher the value of 'C'-factor, the greater is the potential for bond disruption due to polymerization shrinkage.

$$C \text{ factor} = \frac{\text{Bonded surface}}{\text{Unbonded surface}}$$

For class I restoration =  $c = 5$

For class IV restoration =  $c = \frac{1}{4}$

For class III restoration =  $c = 2$

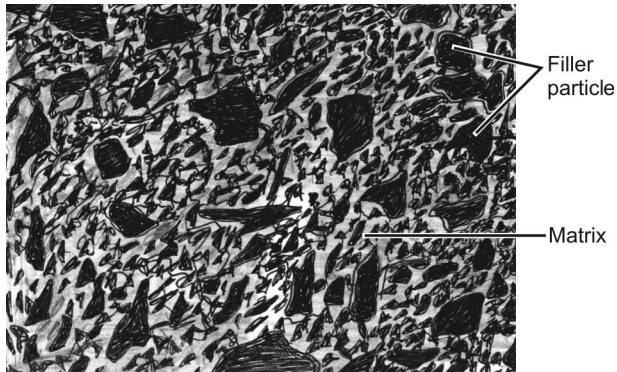
Therefore, class I restorations are at more risk to the effects of polymerization shrinkage. A stress breaking lever like filled dentinal adhesive or RMGI can be used to reduce the effect of polymerization shrinkage and prevent bond disruption.

### TYPES OF COMPOSITE RESINS

Composite resin can be divided into three types based on the size, amount and composition of the inorganic filler:

1. Conventional composite resins
2. Microfilled resins
3. Hybrid composite resins
4. Flowable composites
5. Packable condensable composites

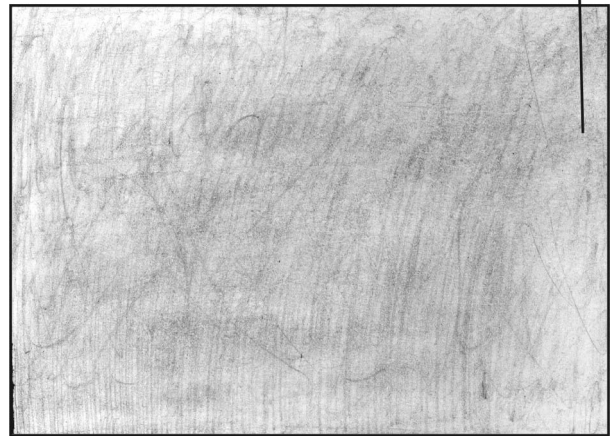
1. *Conventional composite resins:* Average particle size of conventional composite resins is 8 microns (from 5-25 micron) approximately. It contains approximately 75 to 80 percent inorganic filler by weight. It exhibits a rough surface texture because of the relatively large size and extreme hardness of the filler particles. The surface becomes more rough as the resin matrix being less hard wears at faster rate. Due to roughness, discoloration and wearing of occlusal contact areas and plaque accumulation take place quickly than other types of composites (Fig. 24.2).



**Fig. 24.2:** Polished surface of conventional composite restoration as seen in scanning electron micrograph (SEM)

2. *Microfilled resins:* Microfilled resins or polishable composites were introduced in the 1978. Average particle size of microfilled resins ranges from 0.01 to 0.04 microns. This small particle size in place of large size as present in conventional composites results in smooth polished surface which is plaque, debris and stain resistant. Microfilled resins have inorganic filler content of approximately 35 to 60 percent by weight. Most of the studies have observed that the microfilled resins are less susceptible to wear than conventional composite resins. As they contain less filler content, some of their physical properties are inferior (Fig. 24.3).

Microfill composite restoration



**Fig. 24.3:** Polished surface of a microfilled composite restoration as seen in scanning electron micrograph (SEM)

3. *Hybrid composite resins:* In order to combine the advantages of conventional and microfilled composites hybrid composites have been developed. The average inorganic particle size is 0.4 to 1 micron. These materials have an inorganic filler content of approximately 75 to 85 percent by weight. The physical properties of hybrid are similar to those of conventional composites with the advantage of smooth surface texture.
  - A. Considering all factors hybrid type composites are most commonly used.
  - B. Because of their smoothness, they are especially indicated in anterior restorations, but can also be used in posterior restorations. The difference in physical properties of small particle-filled and hybrid is not much, the two terms are often used interchangeably. In both filler particle size approaches one micron and the volume of filler is more than 60 volume percent. All such types of mixtures are collectively called hybrid composites. Attin et al (1996) compared the properties of reinforced modified glass ionomers (RMGI) and polymodified resin glass ionomer cement (PMRC) and concluded that strength properties of RMGI and PMRC were inferior to those of the hybrid resin composite. The main disadvantages of hybrid composites are as follows:



## 236 Textbook of Operative Dentistry

- A. Not suited for heavy stress-bearing areas in posterior teeth
  - B. Not highly polishable as microfilled because larger particles are also present in between smaller.
- In spite of above disadvantages, due to their advantages hybrid composites are most commonly used. Where no specific type of composite is mentioned, it means it is hybrid type.

4. *Flowable composites*: As the name indicates, their consistency is such that they can be flowed into the deep pit and fissure, very small class I, class III, class V and class VII, marginal defects and as a base under hybrid or condensable composites. Their features are as follows:

- A. Filler content is less about 30 percent by weight resulting into inferior physical properties like poor strength and wear resistance in comparison to composites having more fillers. Due to this, their viscosity is reduced and flow is increased.
- B. It sticks to the instrument, hence difficult to smoothen the surface.
- C. High stress areas should not be restored with it.
- D. At one time it can be used only up to a thickness of 6 mm.

*Uses*: Flowable composite is used for the following conditions:

- A. Very small cavities in low stress or stress-free areas.
- B. Repair of leaking and defective margins, filling in deep pit and fissure.
- C. In tunnel cavities
- D. Core building
- E. Repairing and cementing porcelain restorations.
- F. For laminations and veneering
- G. Resurfacing of worn out composite.

Flowable composites are contraindicated in large class I, class II, class IV and class VI cavities.

5. *Condensable (packable) composites*: To improve the compressive, tensile and edge strength and handling, condensable composites have been developed. They are more viscous. Their basis is Polymer Rigid Inorganic Matrix Material (PRIMM). In this, the components are resin and ceramic inorganic fillers are incorporated in network of ceramic fibers. The consistency of the condensable composites is like

freshly triturated amalgam. The composite is carried to the cavity by a carrier whose nozzle is preferably made from or coated with wear, resistant teflon polymer. Each increment is condensed similar to silver amalgam. The cavity is slightly over filled. The excess is removed with a carver. The restorations is light cured for 30 to 40 seconds and finished and polished.

### Advantages of condensable composites over the conventional composites are as follows:

- A. *Increased wear resistance*: Wear resistance is directly proportional to the amount of ceramic fibers present.
- B. *Deeper depth of cure*: Due to light conducting property of the individual ceramic fibers depth of cure is more.
- C. *Increased flexural modulus due to presence of more ceramic fibers per unit area*: Flexural modulus is directly proportional to number of the ceramic fibers present.
- D. *Decreased polymerization shrinkage*: Polymerization shrinkage is indirectly proportional to the number of ceramic fibers present.
- E. *Reduced stickiness*: Stickiness is indirectly proportional to the number of ceramic fibers present.

### Contraindications of Composites

Composite restorations are contraindicated in the following conditions:

1. When operating field cannot be maintained dry.
2. Where very high occlusal forces are present (especially in case of class I, class II and class VI)
3. Some class V restorations that are not esthetically critical.
4. When proper technic cannot be applied.
5. The restorations that extend up to the root surface.
6. Invisible, very small lesions on distal surface of canines where metallic restoration is treatment of choice.
7. Patients with high caries susceptibility and poorly controlled caries activity.

### Advantages of Composites

1. Maximum conservation of tooth structure is possible.
2. Esthetically acceptable.
3. Less complex cavity preparation is required.

4. Insulative, have low thermal conductivity hence no insulation base is required.
5. Restorations are bonded with enamel and dentin hence have good retention.
6. Can be finished immediately after curing.
7. It is repairable.
8. Has low microleakage.
9. Can be used almost universally.

### Disadvantages of Composites

1. Gap formation on margins may occur, usually on root surfaces. This occurs because the force of polymerization shrinkage is greater than the initial bond strength of composite to dentin.
2. More difficult, time consuming and costlier than amalgam.
3. More technique sensitive.
4. Greater occlusal wear in areas of high occlusal stress.
5. High LCTE may result in marginal percolation around composite restorations.

## CLINICAL PROCEDURES

### Initial Clinical Procedures

Complete examination, diagnosis and treatment plan should be finalized prior to going in for a restorative procedure. Following steps are undertaken before starting operative procedure:

- a. *Local anesthesia*: As and when required, local anesthesia is given in many cases, as it contributes to a pleasant, time saving and uninterrupted procedure. Local anesthesia also helps in reducing the salivation.
- b. *Preparing the operative site*: Operating site is cleaned with the help of slurry of pumice. All plaque, calculus and superficial stains should be removed prior to the procedure.
- c. *Shade selection*: The following factors are considered for shade matching:
  - i. The patient and the attendant should be consulted about shade selection.
  - ii. Teeth and shade guide should be wet, both preferably with saliva of the patient during shade matching.
  - iii. Shade matching/selection should be carried out in natural daylight or in the light in which the

patients remain for maximum time of the day. Film and stage actors work in artificial bright light. Their shade should be matched in the same light and not in the daylight.

- iv. To confirm the final shade, a small amount of selected composite is cured on the tooth for matching.
- v. The shade of incisal third is lighter and more translucent than the cervical third. All the three incisal, middle and cervical areas of the anterior teeth have different shades. Hence, shades should be taken accordingly.
- d. *Isolation of the operating site*: Isolation for the tooth-colored restoration can be done by rubber dam, cotton rolls and retraction cord. Isolation of the area is essential if the desired bond is to be obtained. Contamination of etched enamel or dentin by saliva results in a significantly decreased bond. Likewise, contamination of the composite material during insertion results in degradation of physical properties.

## TOOTH PREPARATION FOR COMPOSITE RESTORATIONS

Tooth preparation for composite restorations include the following:

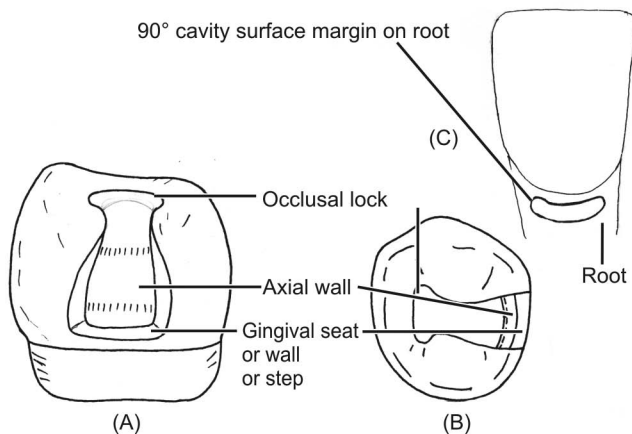
1. Removing all of the caries, fault, defect or old restorative material in the most conservative manner.
2. Creating enamel margin of 90 degrees or greater.
3. Creating cavosurface margin of 90 degrees on root surfaces.
4. Roughening of prepared tooth walls. Retention is obtained primarily from micromechanical bonding of the composite to the roughened, etched and primed enamel and dentin. There is no need for bases under composite restoration, because composite is bonded to the prepared surface.

The following three types of design or their combination of cavities are mostly prepared for composites:

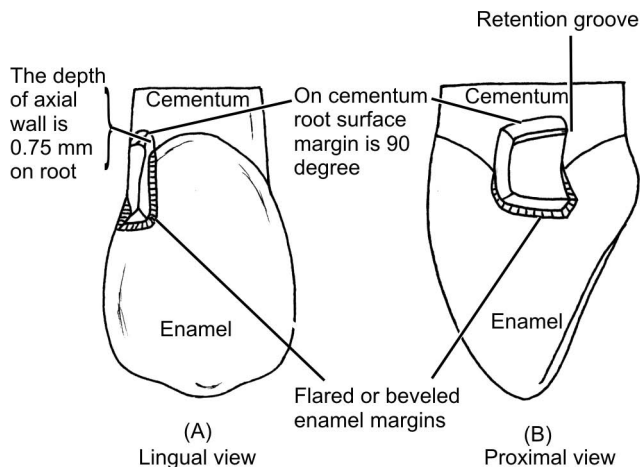
1. Conventional
2. Beveled conventional
3. Modified (conservative).
1. *Conventional*: The primary indications for conventional tooth preparation in composite restorations are preparations located on root surface and moderate to large class I or class II restorations.



Prepared enamel margins should be 90 degree or greater. Ninety degree (butt joint) cavosurface margin should be placed on root surfaces. The prepared tooth structure should be roughened as it increases the bonding. Conventional designs are similar to the cavity preparation for amalgam restoration. Except, that there is less outline extension and in tooth preparation walls being rough (Fig. 24.4).



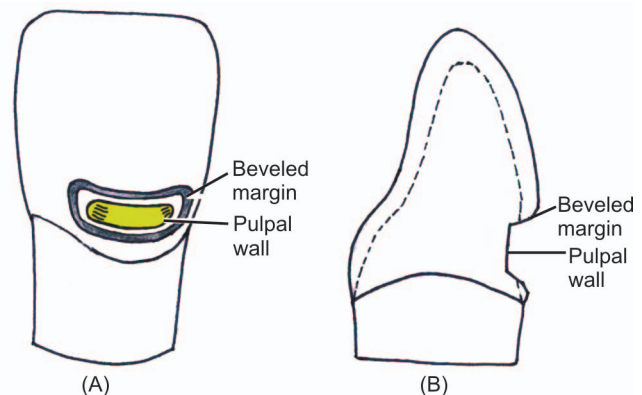
**Fig. 24.4:** (A) Proximal view of class II composite conventional tooth preparation; (B) Occlusal view of class II composite conventional tooth preparation; (C) On root surface class V composite conventional tooth preparation



**Fig. 24.5:** Combination preparation for a class III preparation which is partly on root and partly on crown. The root surface portion is a conventional preparation with 90 degree margins and retention groove in dentin. The enamel surface portion is flared or beveled conventional preparation

In combination preparations, part of the preparation is on crown and part is on root. The root surface portion is prepared as conventional preparation, i.e. 90 degree margins with retention groove in dentin and in enamel surface portion beveled conventional preparation is made where enamel margin is beveled (Fig. 24.5).

2. **Beveled conventional:** This design is almost similar to conventional design except some beveled enamel margins. It is indicated when a composite restoration is being used to replace an existing restoration exhibiting a conventional tooth preparation design with enamel margins or to restore a large area. This design is most typical for classes III, IV, V and VII restorations. Beveled conventional preparation design is rarely used for posterior composite restorations (Fig. 24.6).

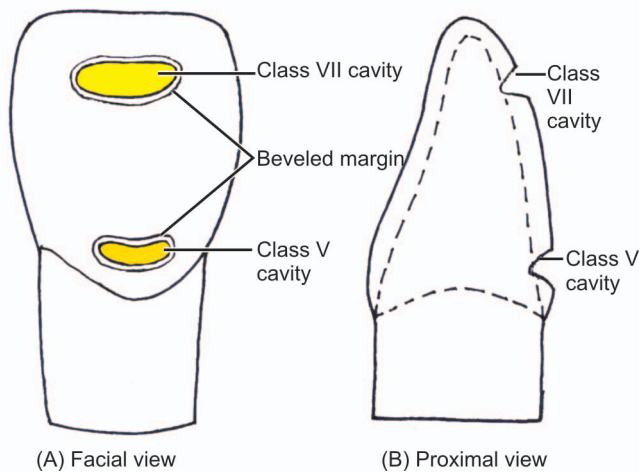


**Fig. 24.6:** Beveled conventional preparation for class V  
(A) Labial view, (B) Proximal view

3. **Modified (conservative):** Modified tooth preparations have neither specified wall configuration nor specified pulpal or axial depth. Both the extension of the margins and the depth of a tooth preparation depends upon the extent and the depth of carious lesion or other defect. It is more conservative in nature as retention is obtained primarily by micro-mechanical adhesion to the surrounding enamel and underlying dentin, rather than by preparation of retention grooves or coves in dentin (Fig. 24.7).

### Acid Etch Technique

Phosphoric acid or citric acid (32 to 37% w/w concentration) is used for acid etching. Acid etching of the dentin results in removal of the smear layer and



**Fig. 24.7:** Modified designs for class V and class VII cavity preparation for direct composite restorations

opening the dentinal tubules. It increases surface area of dentin and of enamel by exposing crystalline structure. The acid is gently applied to the prepared enamel and dentin surface. Application of the acid is repeated to keep the area moist for 15 to 30 seconds. The area is then rinsed with water for 5 to 10 seconds (Figs 24.8 and 24.9).

**Matrix for composite resin:** There are two types of matrices used for composites:

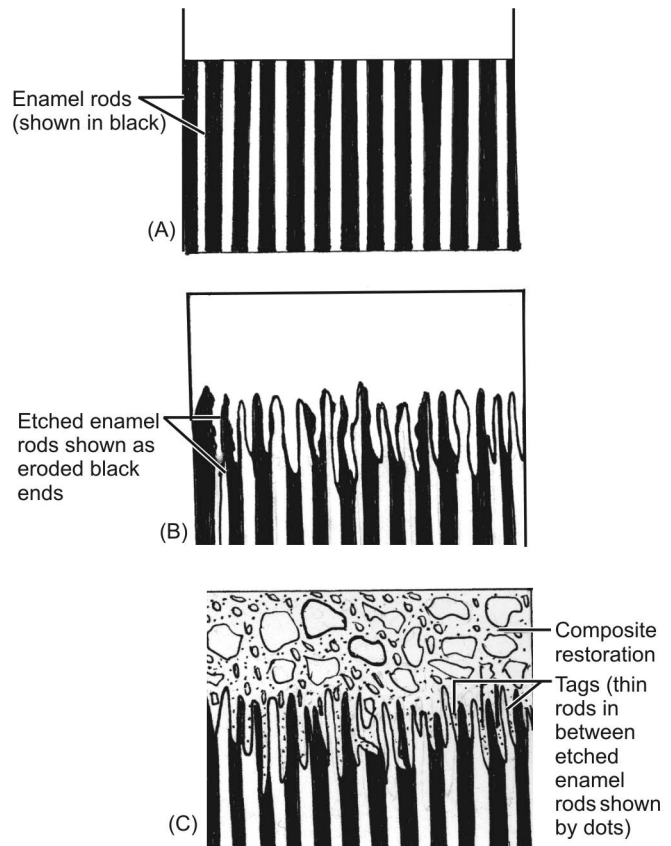
1. Mylar strip matrix
2. Compound supported metal matrix.

## BONDING AGENTS

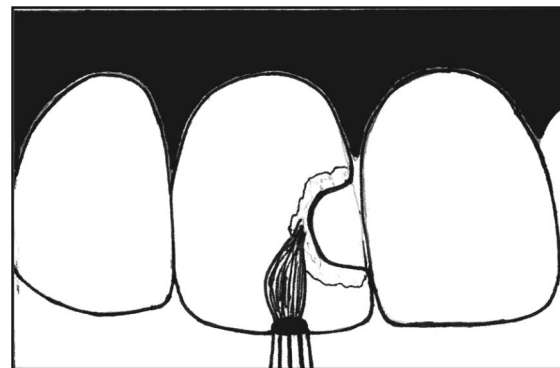
Bonding agents form a strong bond with the tooth structure and also react with restorative resin.

Bonding agents have been classified into two types.

- a. **Enamel-bonding agents:** These are used to increase the wettability of the etched enamel. There is only mechanical bonding between etched enamel surface and bonding agents. Enamel-bonding agents are made by combination of BIS-GMA (bisphenol glyceryl methacrylate) and TEGDMA (triethylene glycol dimethacrylate). These agents are hydrophobic in nature.
- b. **Dentin-bonding agents:** Ideally, the dentin-bonding agent should be hydrophilic in nature. The dentin-bonding agent should contain both hydrophilic part



**Fig. 24.8:** Acid-etching phenomenon, (A) Unetched enamel rods, (B) Enamel rods etched, creating numerous micro-undercuts and (C) Composite material 'TAGS' reached into microundercuts and provide good retention



**Fig 24.9:** Etching of enamel by the application of acid gel by fine brush tip to enamel margin

to interact with moist dentin surface and hydrophobic part to make the bond with restorative resins.

### Instruments for Insertion of Composite Resins

Hand instrument, gun and syringe are used for inserting composite resins.

*Hand instrument:* Hand instrument is a popular method because it is easy and fast. The instrument which is used for insertion of material is made or coated with Teflon. Air trapping during insertion of material is a main disadvantage of hand instrument. 'Packable Composites' can only be used by hand instrument.

*Gun:* Gun which is made up of plastic is used with ampules which are filled with composite. The ampules are fitted in the gun and composite is discharged in the cavity from the ampules.

*Syringe:* The syringe technique is more popular because it provides an easy way for insertion of composite resin into the cavity preparation, as the possibility of air trapping reduces. For this method, viscosity of the composite should be less so that it can flow through needle.

### POLYMERIZATION METHODS

According to their polymerization method, the composite resins can be divided into two broad categories:

1. Self-curing composites
2. Light-activated composites.

#### Self-curing Composite Resin

It is available as a two-paste system composed of a catalyst and a base material. One part contains an organic amine accelerator and the other part includes a peroxide initiator. Catalyst and base materials are usually mixed in a ratio of approximately 1 : 1. Their polymerization process is chemically activated.

#### Light-Activated Composite Resins

Composite resins can be polymerized either by ultraviolet or by visible light. Benzoyl methyl ether is an initiator of polymerization when exposed to ultraviolet light and diketones are used as a photochemical initiator (Fig. 24.8).

*Advantages:* Light-activated composite resins have many advantages over the self-curing composites:

- a. Flexible working time

- b. Better resistance to wear and abrasion
- c. Reduced porosity

### CURING OF COMPOSITES

#### Halogen and Blue Light Emitting Diode Light Curing

Halogen bulb along with filter produces blue light in the range of 410 to 500 nm of visible spectrum. The composite after exposure to this light hardens in about 40 seconds. Gradually, as the bulb gets older curing depth is reduced. The life of the bulb is about 50 hours. A curing light meter is used to check the curing potential of the bulb.

Light-curing units based on light emitting diode technology (commonly used in car indicators) have long life of about 10,000 hours. They require no filters and show negligible reduction of light. Gallium nitrite-based blue light diodes are more powerful and produce power of 3 mW. The blue light of these units is in the range of 400 to 500 nm. It concentrates over a narrower wavelength band. It produces greater depth of curing and does not require a filter (Figs 24.10 to 24.12 and Tables 24.1 and 24.2).

#### Laser Curing

Among all the lasers, Argon laser is most suitable for curing composite. The time required is 10 seconds per increment of 2 mm thickness and the intensity required is 200 to 300 mW. Polymerization shrinkage is same in both types of curings.



**Fig. 24.10:** Composite used for splinting periodontally loose teeth (lingual view)



**Fig. 24.11:** Intraoral curing of light cure composite filling



**Fig. 24.12:** Light cure gun

- i. Low electric diodes (LED) based
- ii. Cord less
- iii. With variable intensity

**Table 24.1:** Comparison of visible light-activated and ultraviolet light-activated systems of composite curing

| <i>Visible light-activated system</i>                   | <i>Ultraviolet light-activated system</i>                                                  |
|---------------------------------------------------------|--------------------------------------------------------------------------------------------|
| 1. The health hazard is virtually eliminated            | 1. Possibility of retinal and soft tissue damage from direct ultraviolet radiation exists. |
| 2. No warm up time is required                          | 2. UV light generation requires several minutes of warm up                                 |
| 3. Less time (20 to 30 sec) required to cure the resin. | 3. Approximately 60 seconds are required to cure the resin.                                |
| 4. Composite material cures to a depth of 2 to 2.5 mm   | 4. Composite material cures to a depth of 1.5 mm only.                                     |

**Table 24.2:** Comparison of laser curing with halogen light curing of composites

| <i>Laser curing</i>                                                                                                                          | <i>Halogen curing</i>                                                                                                                      |
|----------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Advantages</i>                                                                                                                            | <i>Disadvantages</i>                                                                                                                       |
| 1. Curing for about one-third time period is required (10 sec) per increment.                                                                | 1. Curing for about three times of time period is required (30 sec).                                                                       |
| 2. Quality of polymerization is superior. Uniform polymerization is achieved as proximity of laser source to the composite is not necessary. | 2. Quality of polymerization is inferior as closeness of the halogen light is a must for complete curing.                                  |
| 3. Deepest layer is also completely cured.                                                                                                   | 3. Usually deepest layer is not completely cured.                                                                                          |
| 4. Repairing work is more easy.                                                                                                              | 4. Repairing work is difficult.                                                                                                            |
| 5. Curing of all shades is uniformly achieved in lesser time.                                                                                | 5. Darker shades require more time for curing as they have to be cured in thinner layers due to less conduction of light in darker shades. |
| <i>Disadvantages</i>                                                                                                                         | <i>Advantages</i>                                                                                                                          |
| 1. Chances of pulpal damage due to heat are more.                                                                                            | 1. Chances of pulpal damage are less.                                                                                                      |
| 2. Have adverse affects on adjacent restorations.                                                                                            | 2. Does not affect adjacent restorations.                                                                                                  |



## 242 Textbook of Operative Dentistry

For further details on materials, A Textbook of Dental Materials with MCQs' by the authors may be referred.

### Finishing of Composite Restoration

Almost same technique is used for finishing conventional composites and finishing microfilled resins, but there are some differences. Conventional composite exhibits an opaque appearance during dry finish, which makes the cavity margin easy to distinguish. But it is more difficult to detect in microfilled resin because microfilled resin possesses same surface luster as that of tooth enamel.

The occlusal surface is shaped with round carbide finishing burs and overhanging restorations are removed at the proximal margins with flame-shaped carbide burs. The essential contour of larger restorations involving the facial or lingual surface are established with diamond burs. Diamond instruments are very effective for contouring and finishing of all resin systems. In gingival proximal surfaces, narrow finishing strips are used to smoothen the surface.

### Glazing

Placing of a thin layer of unfilled resin over the finished composite resin is known as 'glazing'. Its advantages are as follows:

1. It improves esthetics.
2. It fills surface porosity.
3. It creates a smooth glossy surface which is more resistant to extrinsic staining and plaque retention.

Glazing is more important for a self-curing conventional composite restoration because self-curing composite resin has a more porous surface.

### USES OF COMPOSITES

Composites can be used for the followings:

1. All classes of restorations
2. Esthetic improvement procedures:
  - a. Laminations
  - b. Partial veneers
  - c. Full veneers
  - d. Tooth color improvements
  - e. Diastema closures
3. Foundation and core building
4. Pit and fissure sealant

5. Conservative composite restorations
6. Cementation of indirect restorations
7. Temporary restorations
8. Periodontal splinting (Fig. 24.10)
9. When composites are used properly with all precautions and manufacturer's instructions as per their indications, they may last as much as amalgam. The success of composite also depends on the following factors:
  - A. *Isolation*: For successful bonding of composite with tooth structure isolation of tooth is very important.
  - B. *Occlusal factors*: Composites are less wear resistant than amalgam. In patients with heavy occlusion or bruxism or surfaces exposed to excessive stresses the composites are contraindicated.
  - C. *Ability of operator*: Operator must have both technical ability and knowledge of the use and limitations of the material.

### Antibacterial Composites

In comparison of enamel surface and other restorative materials the plaque and bacteria accumulate much more on the surface of composite resin. Hence, attempts have been made to incorporate the following caries-resistant antibacterials in the composites.

#### Chlorhexidine

Addition of chlorhexidine has been unsuccessful because of the following reasons. Its action was not uniform hence it gave rise to the following disadvantages:

- a. Antibacterial activity is temporary.
- b. Deterioration of all the physical properties takes place.
- c. Released materials have toxic affects.
- d. Microorganisms and plaque shift to adjacent areas of the tooth.

#### Methacryloxydecyl Pyridinium Bromide (MDPB)

Its use was recommended by Imazato et al (1994). It has the following properties:

- a. On curing, it chemically binds to the resin matrix, hence no release of any antibacterial component takes place.
- b. Its antibacterial property remains constant and permanent.

- c. It is effective against various streptococci.
- d. It has no adverse effect on the physical properties of BIS-GMA based composites.

### **Silver**

Addition of silver ions in the composites also makes them antibacterial.

The silver ions are not released. Their antibacterial property is due to direct contact with bacteria. Silver ions can be added in any of the following methods:

- a. Incorporated into inorganic oxide-like silicone dioxides.
- b. Incorporated into silica gel and the thin films are coated over the surface of composites.
- c. Hydrothermally supported into the space between the crystal lattice network of filler particles. Silver ions cause structural damage to the bacteria.

### **Effects on the Properties**

Addition of silver into composite without silica gel does not adversely affect its physical properties like depth of cure, compressive strength, tensile strength, color stability, translucency and polymerization.

### **Expanding Matrix Resins for Composites**

Like silver amalgam, slight expansion of the composite during polymerization is desired. This reduces marginal leakage, postoperative sensitivity and facilitates bulk placement of the material. Spiro-orthocarbonates (SOCS) expand on polymerization.

Epoxy resin contract 3.4 percent and SOCS expand 3.6 percent. Both are mixed to achieve desired expansion.

## **CURRENT OPINIONS**

### **Bases and Liners Under Composite Restorations**

Some workers have recommended the use of RMGIs, compomer, flowable composite and fast-setting calcium hydroxide as bases and liners under composite restorations for providing better seal, pulp protection, acting as a stress breaker and to resist polymerization stresses.

Most of the workers are of the opinion that there is no need of such liners and bases to be used routinely as etching will not be possible in dentin covered with such bases and liners. However, to protect the pulp

under very deep cavity a thin lining of fast-setting calcium hydroxide may be given in selected teeth.

### **Retention Grooves Where Dry Field cannot be Achieved for Bonding for Filling with Composites**

If dry field can be achieved, bonding should provide sufficient retention in enamel and dentin cavities. However, where dry field for bonding cannot be achieved, rounded retention grooves must be provided for retention in all classes of the cavities for restoration with composites.

### **Occlusal Load on Composite Restorations**

Wear resistance of 'packable posterior composites' is almost equal to amalgam. Where more than fifty percent of occlusal contacts are shared by the tooth structure, 'packable posterior composites' can successfully replace amalgam to provide esthetic composite restorations.

### **Recurrent Caries due to Interface Gap with Cementum in Composite Fillings**

As bonding with cementum is weak, usually after a few months 'V- shaped' gap may appear at the interface margin in which recurrent caries may appear. This problem can be solved by giving lining of RMGI under the composite. This will reduce the total thickness of the composite, hence the V-gap will be very much reduced or eliminated; thereby chances of recurrent caries will be reduced or eliminated.

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# 25 *Direct Tooth-Colored Restoration for Classes III, IV, V and VII Cavity Preparations*

The search for ideal tooth-colored restorative material is continuing for the last many centuries, but all the requirements are not satisfied by any material till now. An ideal esthetic material is not available even today which can fulfill all important requirements of an ideal filling material. The treatment planning and selection of the restorative material affect the esthetics. In the anterior restoration, esthetics is directly related to color and translucency of the restorative materials. For posterior teeth, indirect inlays/onlays and ceramic restorations have been described which are costly, require laboratory facility and more number of sittings. These materials have advantage of having superior esthetics over gold and amalgam.

Ceramic inlay has many characteristic features like excellent esthetics, dimensional stability and durability. Composite materials can be used for successful classes I, II and VI cavity designs, if the proper operative techniques are performed. When compared with metallic restorations, composite materials have bonding ability with dental tissues, better esthetics, marginal integrity, low thermal conductivity and almost no toxicity.

## **PRESENT STATUS OF TOOTH-COLORED RESTORATIONS**

Formulations of ideal tooth-colored restorative materials for high stress-bearing areas possess the following general features with improved properties. Smaller size of primary filler particles increases the amount of radiopaque filler and decreases the amount of resin matrix which enhances the stiffness and strength and are compatible with tooth with the help of bonding agents. The proper operative procedures and manipulation of material are essential to ensure the optimal results. The American Dental

Association (ADA) Council of Dental Materials under the acceptance program has not recognized any composite material as an amalgam substitute (Table 25.1).

## **DIRECTLY BONDED COMPOSITE RESTORATIONS**

### **Advantages**

In comparison to amalgam restoration of classes I, II and VI cavity preparation, the main advantages of directly bonded composite restorations are as follows: (1) Good esthetics, (2) Can bond to tooth structure, (3) Conservation of remaining tooth structures, (4) Low thermal conductivity, (5) No corrosion. The attempts have been made to bond amalgam to tooth structure, but the bond is not as strong as with composites. In comparison to porcelain and gold, composites are less expensive.

### **Disadvantages**

The main disadvantages of composites are the following:

1. Techniques are very sensitive.
2. Low modulus of elasticity and poor wear resistance in high stress areas.
3. Low compressive strength.
4. Discoloration after few years.

### **Indications**

1. All small cavities when esthetics, cost and number of sittings are main considerations.
2. Small class I, class II and class VI defects as hypoplasia, hypocalcification, carious lesions preferable with enamel margins.
3. Abrasion and erosion in uncontrollable sensitivity or esthetically important areas.



**Table 25.1:** Problems, causes and remedies associated with composite restorations

| Problems                                            | Causes                                                                                                                                                                                                                                                                             | Remedies                                                                                                                                                                                                                                                                           |
|-----------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Pain due to pressure at a point over the filling | Presence of small air bubble between filling and dentin. On pressure due to resiliency, the composite is slightly pressed and air bubble is also pressed. On being pressed, air bubble enters the exposed dentinal tubules thereby pressing the nerve endings resulting into pain. | Refilling with more care to avoid entrapment of any air bubble.                                                                                                                                                                                                                    |
| 2. Poor surface of restoration                      | a. No use or faulty use of rubber dam<br>b. Poor technique<br>c. Deep gingival preparation where isolation is difficult.                                                                                                                                                           | a. Better technique<br>b. Use of matrix<br>c. Use of fine filler particle restorative material<br>d. Repeat etching, priming and adhesive placement.                                                                                                                               |
| 3. Incorrect shade                                  | a. Inappropriate light during shade selection<br>b. Tooth is dry during shade selection<br>c. Wrong shade selected.                                                                                                                                                                | a. Use of natural light for shade selection<br>b. Selection of shade before isolation<br>c. Understand the typical zones of different shade of natural teeth                                                                                                                       |
| 4. White line or halo around the margin             | a. Traumatic contouring or finishing technique<br>b. Inadequate etching or bonding<br>c. High intensity light curing.                                                                                                                                                              | a. Use atraumatic finishing technique<br>b. Apply primer and bond the area<br>c. Use slow start polymerization technique                                                                                                                                                           |
| 5. Voids                                            | a. Faulty mixing of self-cured composites<br>b. Space left between increments<br>c. Composite with large filler particles.                                                                                                                                                         | a. More careful technique<br>b. Repair of marginal voids by preparing the area and restoring with fine filler particles.                                                                                                                                                           |
| 6. Weak or missing proximal contacts                | a. Inadequately contoured matrix bands.<br>b. Inadequate wedging.<br><br>c. Movements of matrix band during composite insertion<br>d. Too thick matrix band<br>e. Composite pulling away from matrix contact area.                                                                 | a. Use of thin matrix band and firm wedging technique<br>b. Properly contour the matrix band<br>c. Matrix band should contact the adjacent tooth<br>d. Place matrix only around the proximal surface to be restored<br>e. Hold the matrix against the adjacent tooth while curing. |
| 7. Poor retention                                   | a. Inadequate cavity form<br>b. Contaminated operating area<br>c. Poor bonding technique                                                                                                                                                                                           | a. Place bevels, flares or secondary retentive features<br>b. Keep the area isolated during bonding<br>c. Do not intermingle bonding materials from different system and make.                                                                                                     |
| 8. Contouring and finishing problems                | a. Injury to adjacent unprepared tooth structure<br>b. Overcontoured restoration<br>c. Undercontoured restoration<br>d. Ditching in cementum<br>e. Inadequate anatomic tooth form                                                                                                  | a. Careful use of rotatory instruments<br><br>b. Use of contoured matrix.<br>c. Use of properly shaped instrument<br>d. Create embrasure to match the adjacent tooth embrasure form                                                                                                |

4. Veneers for metal restorations.
5. Repair of fractured teeth.
6. Interim restorations.

### **Contraindications**

1. Areas which cannot be isolated.
2. Areas with heavy occlusal forces.

Mostly, composites are restored directly. Always classes III, IV, and VII and mostly class V cavities are esthetically important and are on less stress-bearing areas, hence composite which is esthetically acceptable is suitable for these cavities. Due to bonding of composites to tooth tissues, minimum removal of healthy tooth tissues during tooth/cavity preparation is required. For adequate retention, good bonding is essential which can be obtained only after proper isolation.

## **DIRECT CLASS III COMPOSITE RESTORATION**

### **Initial Clinical Procedures**

1. *Local anesthesia if required:* Profound local anesthesia may be given before tooth preparation (if dentin is excessively sensitive) which results in the patient's comfort and reduction in salivary flow which is very important in case of bonded restorations for better bonding.
2. *Preparations of site:* Operating site is cleaned with a slurry of pumice to remove plaque, pellicle superficial stains. Calculus, if present, is also removed. These procedures create a site more receptive to bonding.
3. *Shade selection:* The shade of natural tooth must match with the composite material. The shade of the tooth should be determined before isolation as after isolation, the tooth dehydrates and translucency is decreased. Composite material is selected according to the tooth color from shade guides provided by manufacturers. Most manufacturers cross reference their shades with those of VITA Shade Guide (universally adopted shade guide) (see Fig. 7.3). The composite materials are available in enamel and dentin shades as well as translucent and opaque shades. Enamel shades are more translucent. Good lighting, either natural or artificial is necessary when the shade

selection is done. Natural light is preferred. Mostly shade selection should not take more than 30 seconds because the fine sensitivity of eyes to differentiate between different shades of similar color is exhausted. The eyes should be given rest by looking at blue and violet colors which are complementary colors for yellow and orange. Final selection must be confirmed by the patient with the use of a face mirror. It is better to use the shade of slightly darker side to allow for age-related darkening in color of teeth.

### **Tooth Preparation**

Depending upon the type of dental tissues involved, the cavity for the composites can be prepared in three designs, conventional, beveled conventional and modified (conservative) (Fig. 25.1A).

### **Conventional Class III Tooth (Cavity) Preparation**

The main indication for this type of cavity preparation is damage on the root surfaces. Mostly, damage observed is partly on the root and partly on crown. The cavity on the root is prepared in conventional method. The cavity on the crown is prepared in beveled conventional or modified type. Hence, the design of the cavity is a combination of a modified or a beveled conventional on the crown portion and conventional on the root surface. When the damage is only on the root portion, then the conventional cavity will be only on the root with butt joint (90 degree) cavosurface margins like class V cavity for amalgam. The external walls are perpendicular to the root surface. The preparation must ensure (a) adequate removal of caries/old filling/damage, and (b) retention grooves if required. Retention grooves may be required on root surface cavity to increase the retention and the marginal seal. Where caries is not deep, the wall depth in dentin is usually about 0.75 mm. Initially, 0.75 mm deep cavity is prepared; then wherever caries is left out, it is removed.

In the crown portion of the cavity, the retention is mostly provided by adhesive bonding to enamel and dentin.

The following are important points in conventional cavity preparation:

- A. The external walls should be located on sound tooth structure with a cavosurface angle of 90 degrees for

## 248 Textbook of Operative Dentistry

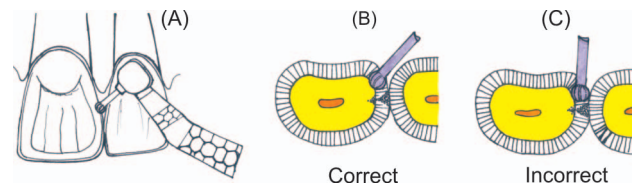
butt joint relation. External walls should be perpendicular to tooth surface.

- B. Minimum pulpal depth of axial wall should be approximately 0.75 mm into dentin.
- C. Adequate access for removal of remaining infected dentin and old restorative material using spoon excavators or round burs. A calcium hydroxide  $[\text{Ca}(\text{OH})_2]$  liner for pulp protection should be applied only if indicated.
- D. Continuous groove or isolated grooves may be placed for extra retention. Continuous groove is placed in external walls, parallel to tooth surface. It should be located at least 1 mm from the tooth surface and at least 0.5 mm deep into dentin.
- E. This type of cavity preparation leads to the formation of box preparation as done in amalgam. Retention in such preparation is provided by the following (Figs 25.1 and 25.2):
  - a. Rough surface of prepared cavity.
  - b. Parallelism or convergence of opposing external walls, if present.
  - c. Retention grooves and coves (Figs 25.3 to 25.7).

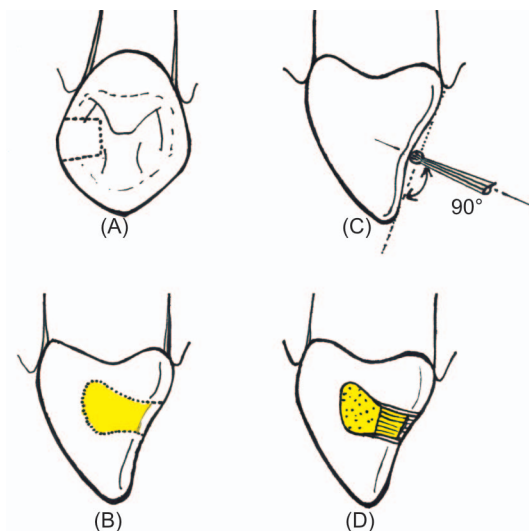
### BEVELED CONVENTIONAL CLASS III TOOTH CAVITY PREPARATION

This type of class III preparation is primarily indicated for replacing an existing defective restoration on crown portion of an anterior tooth or when restoring a large carious lesion which will require increased retention form. Mostly, the area is approached lingually with a no  $\frac{1}{2}$ , 1 or 2 round bur entering the area within the incisogingival dimension of carious lesion/restoration, close to the adjacent teeth, without touching it. Entry angle should be such that it places the neck portion of the bur far into the embrasure. While preparing a beveled conventional class III cavity, the following requirements must be met:

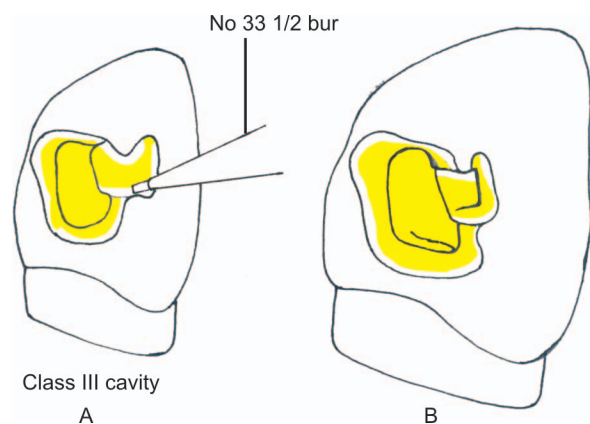
- i. Shape of the prepared cavity should be similar to the shape of existing lesion/restoration and should include any recurrent caries, friable tooth structure and defects while placing the external walls on sound tooth structure.
- ii. Initially, the axial wall depth should be 0.2 mm inside DEJ, pulpally. This places the axial wall 0.75 mm deep gingivally and 1.25 mm deep incisally. Also, the axial wall should be convex outwardly (Fig. 25.8).



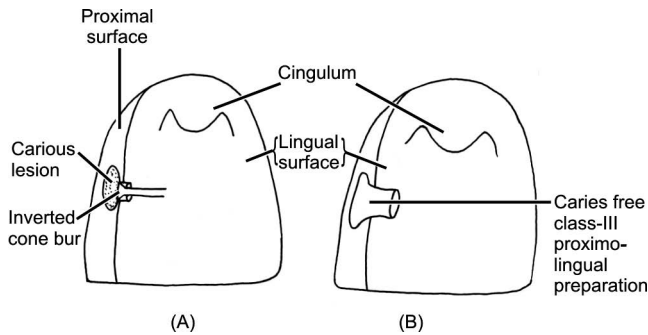
**Fig. 25.1:** Class III conventional cavity preparation, lingual approach. (A) Bur is perpendicular to enamel surface, (B) Correct angle of bur placement is parallel to enamel rods, (C) Incorrect entry overextends the surface of lingual outlines



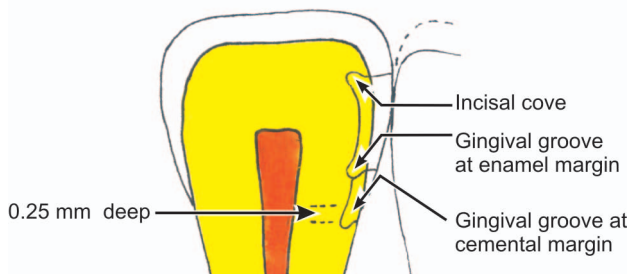
**Fig. 25.2:** External outline of class III cavity of maxillary canine (A) Lingual view (B) Proximal view (C) Initial penetration of round bur is perpendicular to the lingual surface (proximal view) (D) Final cavity prepared (proximal view)



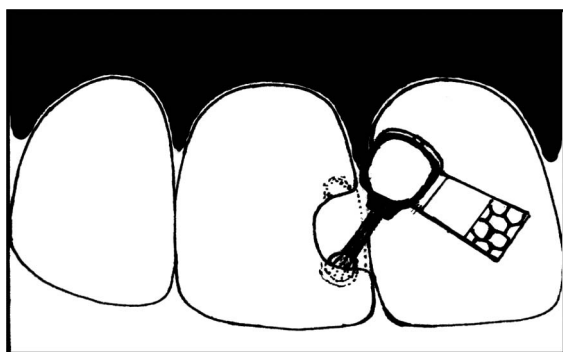
**Fig. 25.3:** Class III cavity preparation with retention coves in lingual dovetail (A) Cutting retention cove by No 33½ bur, (B) Arrow indicates that dentinal support of lingual enamel is not removed by preparation of cove



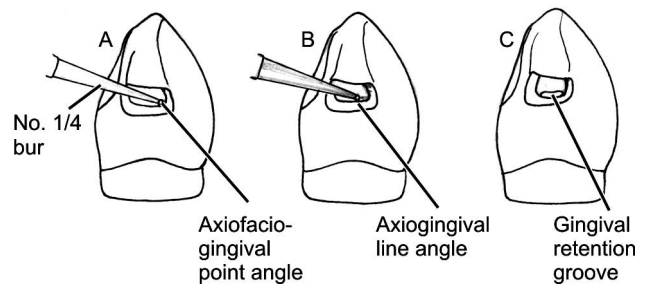
**Fig. 25.4:** Class III cavity preparation in maxillary central incisor (A) Approach through proximolingual marginal ridge by inverted cone bur, (B) Caries-free class III proximolingual preparation



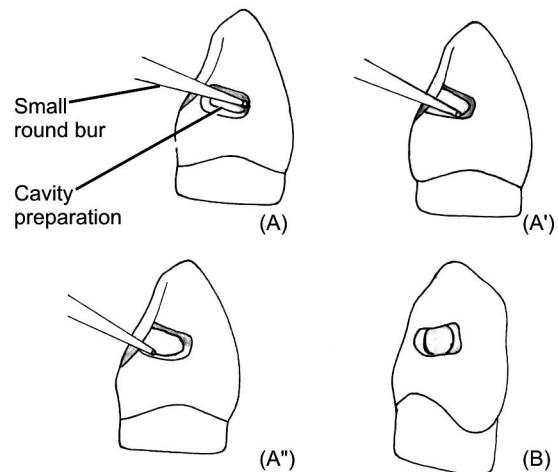
**Fig. 25.5:** Class III cavity-Mesiodistal longitudinal section of tooth showing location and depthwise direction of groove (arrows) for retention in class III cavity preparation of different gingival depths. The distance from the margin to the outer aspect of gingival groove at cemental margin is 0.25 to 0.3 mm. Diameter of bur used is 0.5 mm and depth of groove is half this diameter, i.e. 0.25 mm. For preparing cove and groove on axial wall dental depths are in enamel- 0.5 to 0.6 mm and in cementum- 0.75 to 0.8 mm



**Fig. 25.6:** Preparation of incisal retention groove with round bur in class III cavity



**Fig. 25.7:** Class III cavity- Preparation of gingival retention groove (A) No 1/4 bur is placed in axiofaciogingival point angle, (B) Bur is moved lingually along with the axiokingival line angle for preparation of groove, (C) Gingival retention groove is prepared



**Fig. 25.8:** Class III cavity-Proximal portion is refined by using a small round bur. (A, A', A'')- Cavity walls are shaped, axial line angles are accentuated and undermined enamel at gingival and facial margins is removed, (B) Cavity preparation is complete except for final finishing of enamel margins and giving retention form

- iii. All remaining infected dentin or defective restoration should be removed during final cavity preparation using spoon excavator or round bur. A calcium hydroxide cavity liner should be placed only if indicated, for pulp protection.
- iv. External walls should be perpendicular to the enamel surface with all enamel margins beveled. The bevel should be about 0.2 to 0.5 mm wide and at an angle of 45 degrees to the external tooth surface. These bevels should be prepared using flat end tapering fissure diamond bur at



cavosurface margins in the areas of centric contacts. Areas bearing heavy occlusal forces should not be beveled. If the preparation extends gingivally onto the root surface, no bevel is placed on cemental cavosurface margins (Fig. 25.9).

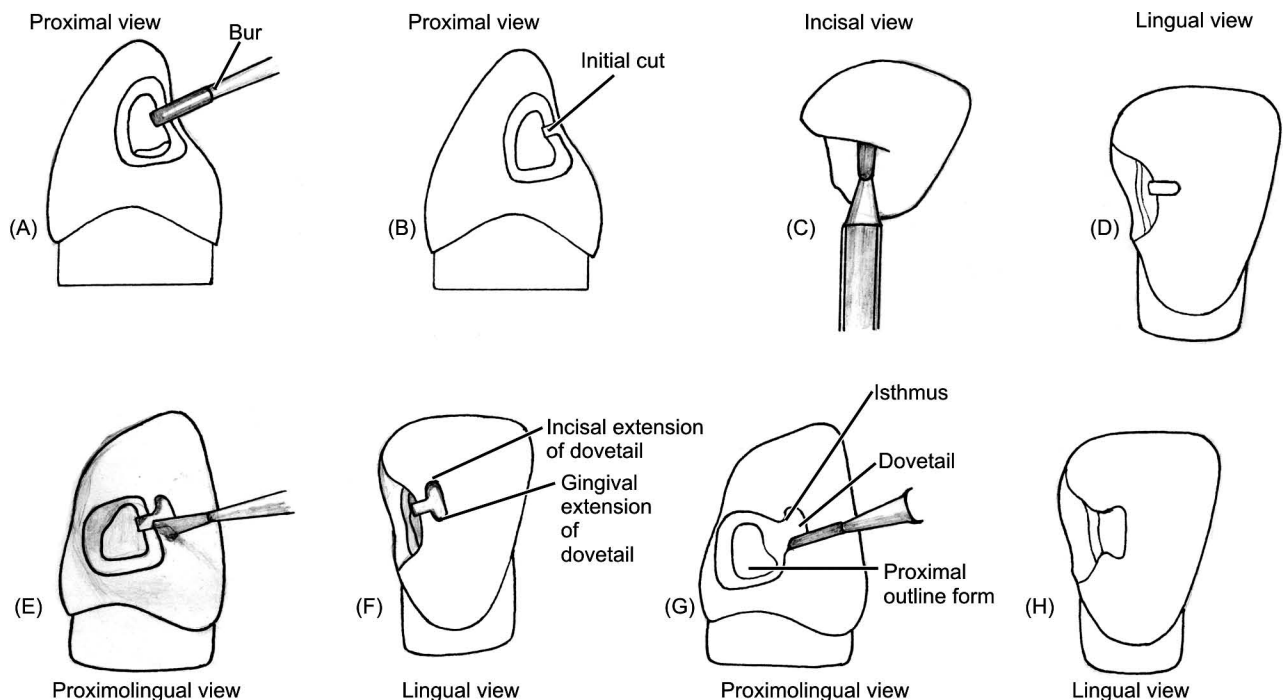
- v. Usually no secondary retentive feature is required. However, retentive groove (gingivally) and coves (incisally) can be prepared along gingivoaxial line angle and incisoaxial line angle, respectively, using No 1/4 or 1/2 round burs. These grooves should be 0.2 mm inside DEJ and 0.25 mm deep without undermining the enamel.
- vi. Some undermined (but nonfriable) enamel can be left intact, if it is not in a high stress-bearing area.

### MODIFIED (CONSERVATIVE) CLASS III TOOTH PREPARATION

It is primarily indicated for small and moderate lesions and damages. It is the most conservative type of cavity

preparation used for composites. The objective here is to include only the infected carious area as conservatively as possible by “scooping” out the defective tooth structure. Thus, the preparation design appears to be ‘scooped-out’ or ‘concave’. Mostly, the lesion or damage is approached lingually using small no. 1/2, 1 and 2 round bur. The design and extent of the preparation is governed by the extent of the damage. While preparing a class III modified cavity, the following points should be kept in mind:

- i. The bur position and angulations during entry is same as that for previous type of cavity preparation.
- ii. For smaller preparations, there may not be any definite axial wall depth, and the walls may diverge externally from axial depth in a scoop shape.
- iii. For larger preparations an initial axial depth of 0.2 mm below DEJ may be maintained, and the walls may not diverge externally from axial wall itself.



**Fig. 25.9:** Class III cavity-Lingual dovetail is prepared for large composite restoration to provide additional retention, (A) Correct depth and angulation of bur to begin cutting, (B) Initial cut, (C) Movement of bur to most mesial extent of dovetail, (D) If possible, extension of cutting should not reach beyond midlingual position, (E) Preparing gingival extension of dovetail, (F) Gingival and incisal extensions of dovetail, (G) Preparing the incisal and gingival walls of isthmus in smooth curves connecting the dovetail to proximal outline form, (H) Completed lingual dovetail

- iv. Remaining infected dentin should be removed using small burs or spoon excavators, and a calcium hydroxide liner should be placed, if indicated.
- v. Smaller preparations may not require any beveling of margins as they typically have a beveled or flared marginal configuration from initial tooth preparation.
- vi. Larger preparations do require additional beveling or flaring during final tooth preparation. The cavosurface margins are beveled using flat end tapering fissure diamond bur to have a width of 0.2 to 0.5 mm and an angle of 45 degrees to external tooth surface.
- vii. Usually, no additional retention groove or cove is required.
- viii. Undermined enamel may be left intact if not friable, and not located in/under stress-bearing area.
- ix. Finally, the cavity should be cleaned and finished.

## **RESTORATIVE TECHNIQUE**

### **Etching of the Prepared Cavity**

Firstly, the proximal surface of adjacent unprepared tooth should be protected from inadvertent etching by covering it with a polyester strip. A gel etchant is then applied with a syringe or brush to the prepared cavity surfaces, approximately 0.5 mm beyond the cavosurface margins onto the unprepared tooth surface. The etchant is left there for 15 seconds, if dentin is included and for 30 seconds if only enamel is involved. Then wash the area to remove all the etchant for 5 seconds. The area is then dried if only enamel has been etched but left moist if only dentin is involved in the cavity preparation. The moist dentin has a glistening appearance. If dentin has been dried, it can be rewetted with water saturated applicator tip. The dried etched enamel, on other hand, exhibits ground glass or frosted appearance.

## **APPLICATION OF PRIMER AND ENAMEL DENTIN-BONDING AGENTS**

After etching, a primer and an adhesive are placed if both enamel and dentin are involved, but only adhesive is required for an all enamel cavity preparation. Bonding systems are available in different forms, depending on

the manufacturer. Components of one system are not interchangeable with another system. Most contemporary bonding systems, combine the primer and adhesive into a single bottle requiring only one application. In these cases application of primer to enamel, though not required, does not result in any adverse effects on bond strength of composite. Disposable brushes or applicator tips are used for applying the adhesive agents. If the system does not contain both primer and adhesive, then bonding adhesive is applied after the primer by using a separate brush or applicator tip. Thereafter, the adhesive is polymerized with curing light. An oxygen-inhibited layer on surface is always present.

### **Matrix Application**

A matrix helps in confining the excess restorative material and in development of appropriate axial tooth contours. It also helps in isolating the prepared tooth. The matrix should be applied and stabilized by a wedge before application of etchant, primer and adhesive. This is more important where the tooth preparation is gingivally deep. A properly contoured, wedge supported, clear polyester strip matrix is indicated for class III restorations. The matrix should extend one mm beyond the incisal and gingival cavosurface margins. The functions of wedge at the gingival margin are: (a) to hold the strip into position, (b) to provide slight separation of teeth to compensate for thickness of matrix, and (c) to prevent the gingival overhang of the material (Fig. 25.10).

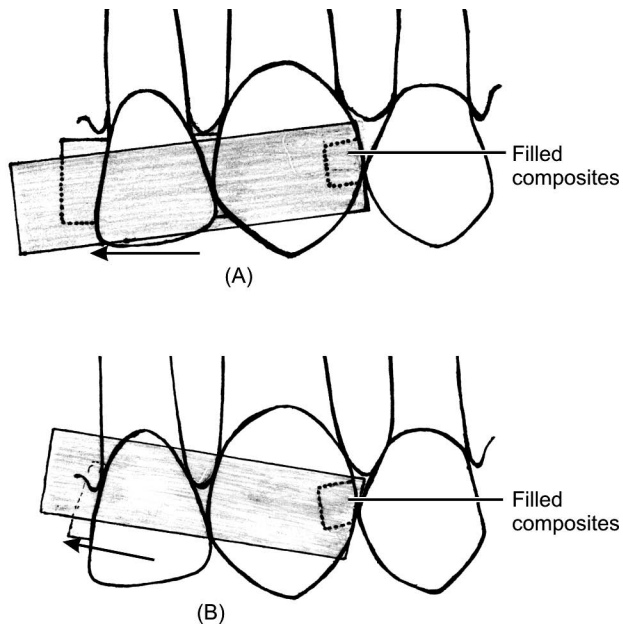
### **Insertion and Curing of Composite**

The composite material is usually placed in two stages:

- i. A bonding adhesive is applied (if not done already).
- ii. Light-cured/self-cured composite restorative material is inserted.

### **Placing Self-Cured Composite**

The base and accelerator paste for bonding adhesive is mixed on a pad and immediately applied to etched enamel and primed dentin with a microbrush. Simultaneously, base and catalyst paste of self-cured composite material of selected shade are mixed on another pad for 30 seconds and inserted into the cavity after bonding adhesive has been applied. A syringe or hand instrument is used to place and spread and

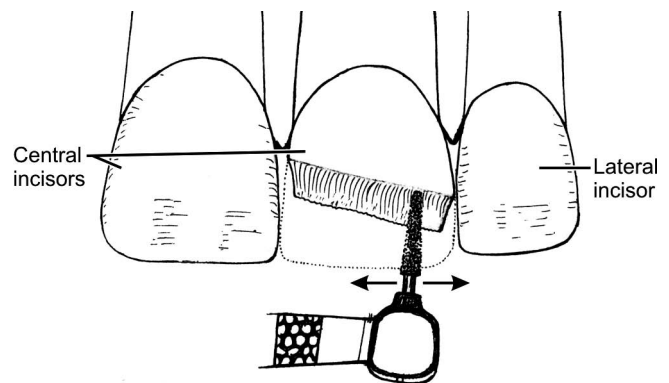


**Fig. 25.10:** Angle of pull of mylar matrix strip for composite resin. (A) Mylar matrix pulling towards (incisally) tightens the strip at the cervical margin to extrude excess material incisally and minimize cervical overextension, (B) Mylar strip is pulling in gingival direction open matrix in cervical direction to extrude the excess material cervically

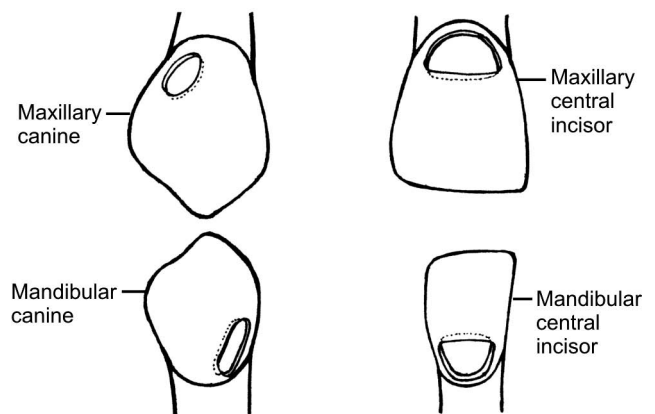
condense the composite into the tooth preparation. A plugger is next used to press the material into retentive areas. The material is added in two or three increments and should take less than one minute for insertion. The cavity should be filled to a slight excess so that positive (condensing) pressure can be applied with matrix strip. Any gross excess should be removed by the sharp spoon excavator or side of explorer before closing the matrix. Close the lingual end of strip over the composite followed by the facial and tighten the matrix using pressure from fingers holding the strip. The matrix should be held for about three minutes, until polymerization is complete and the composite hardens. After the composite has hardened, the wedge and matrix strip should be removed.

### Placing Light-Cured Composites

Light-cured materials usually include an enamel/dentin bonding agent and numerous syringes or self-contained syringe tips of various shades of composite. Light-cured



**Fig. 25.11:** Class IV tooth-colored restoration with labial and lingual chamfer to increase bonding area, to increase retention



**Fig. 25.12:** Various outline forms of class V cavity

materials do not have to be mixed and are not dispensed until ready for use. The bonding adhesive is applied to the etched and primed enamel/dentin using foam sponge, microbrush or applicator tip. The adhesive is then cured for 10 to 20 seconds using visible light. Now the light-cured composite is inserted in increments of thickness of about 2 mm each by hand instrument or syringe. Once the material has been inserted, it is cured for 20 to 30 seconds by holding the light source close to but not in contact with the restorative material. Longer exposure to light is required for darker and opaque shades. Each increment is added and cured till the complete cavity is filled (see Figs 24.11 and 24.12).

### **Composite Restoration**

Contouring can be initiated immediately after placing the final increment of the material in the cavity and completed before a light-cured composite material has been completely polymerized or before the hardening of a self-cured material. If the technique is good and done by experienced hands, only slight excess of material after curing remains to be removed. Finishing burs, disks or special composite-finishing fine-diamond points should be used for finishing at low-to-medium speeds with light intermittent brush strokes and a coolant should be used with contouring. A flame-shaped fine carbide-finishing bur or polishing diamond is used on facial surface. Flexible abrasive disks can also be used on facial surface. A round, inverted pear-shaped and oval 12 bladed carbide-finishing burs are used on lingual surface. The contours and margins on proximal area are checked visually and by tactile sensation with explorer and dental floss. A sharp no 12 surgical blade in BP handle or gold finishing knife contouring, is used for contouring and finishing of composite filling at gingival margin.

### **Final Contouring, Finishing and Polishing of Composite Restorations**

Final contouring, finishing and polishing of a class III composite restoration is done with finishing diamond points. Polishing is done with rubber-polishing point and an aluminum oxide polishing paste. Fine grit disk, white stone and fine abrasive finishing strips can also be used for final finishing and polishing.

## **DIRECT CLASS IV COMPOSITE RESTORATION**

Class IV restoration is usually required when an accident or extensive caries destroys or severely weakens the incisal angle.

### **Initial Clinical Procedures**

Same sequence of initial clinical procedures is followed, as done for class III restorations. Preoperative assessment of occlusion is more important for class IV restorations. Occlusal factors may dictate a more conventional tooth preparation with more resistance features and secondary retention form features. Also, the wedge should be placed before tooth preparation, if the proximal contact has to be restored. The esthetics or

color matching is more critical because of the size of restoration and location.

### **Tooth Preparation**

#### **Conventional Class IV Preparation**

Conventional type of class IV design is indicated only in those areas that have margins on root surface. A beveled conventional preparation is indicated for a large class IV lesion, while the modified preparation is done in small class IV cavity or traumatic defect. However, the preparation in high stress area is more of a conventional type (Fig. 25.11).

## **BEVELED CONVENTIONAL CLASS IV PREPARATION**

A beveled conventional class IV preparation used to restore large areas may require grooves, undercuts, dovetail, threaded pins or any combination for additional retention. Pin-supported retention, though usually avoided, may become necessary when a large amount of tooth structure is missing. One or two TMS-threaded pins can be placed in the gingival wall. The walls should be parallel and perpendicular to the long axis of tooth.

The initial axial wall depth is established at 0.5 mm pulpally to DEJ. Bevels are prepared at 45 degree angle to tooth surface with a width of 0.25 to 2 mm, depending on the amount of retention required. Retentive grooves are made in the same way as in class III beveled conventional preparation. The instruments used for cavity preparation are almost same.

## **MODIFIED (CONSERVATIVE) CLASS IV PREPARATION**

It is prepared, keeping in mind the same objectives as those applied for modified class III preparation. The technic, procedure and instruments are also the same. Usually, little or no initial tooth preparation is indicated for fractured incisal corners, other than roughing the fractured tooth structure.

## **RESTORATIVE TECHNIQUE**

- a. *Etching, priming and adhesive placement:* These procedures for class IV composite restorations are same as described earlier in class III preparation.



- b. *Matrix placement:* For small class IV preparations, a flexible polyester matrix strip can be placed and wedged (gingivally) as done in class III preparation. A fold should be given in the strip at the position of lingual line angle to prevent undercontoured restoration in this area. Incisally, it should not protrude more than 1 to 2 mm beyond incisal edge. For large class IV preparation, an impression compound supported metal matrix is required.
- c. *Inserting, curing and contouring:* After matrix placement, etching and adhesive placement, the composite is inserted into the cavity using hand instrument or syringe (gun). Either self-cured or light-cured material of selected shade can be used. Composite is inserted preferably using syringe. Matrix should not be closed too tightly as it would result in an undercontoured restoration. A slight excess of material should be provided at the exposed margins. Alternatively, a readymade, or a pre-fabricated plastic crown of desired shape can be used, for large restorations. A light-cured material is inserted preferably with a hand instrument up to 1 to 2 mm in thickness and cured. The curing should be done from both facial and lingual surfaces. This whole process should take approximately 4 to 5 minutes after which the matrix strip is removed.
- d. *Final contouring and polishing of the composite:* After the material has hardened and matrix removed, the class IV composite preparation should be contoured and finished in the same way as described for class III composite restoration. However, contouring and finishing of incisal cover and edge of the tooth require special attention.

## DIRECT CLASS V AND VII COMPOSITE RESTORATIONS

Various factors are associated while making the choice of material for class V and VII preparations. Such factors include location and extent of lesion/damage, esthetics, access and salivary flow, caries activity, etc. Usually, composites are material of choice in those class V and in all class VII cavities which are esthetically prominent (see Figs 8.45 to 8.50 and 8.53).

Among composite materials, microfill composites should be used for restoration of class V and class VII cavities because they provide better and more smooth

surface and have sufficient flexibility to resist stresses caused by cervical flexure, when tooth flexes under heavy occlusal forces.

### Initial Clinical Procedures

Each of the initial step deserves special consideration while restoring class V and VII lesions. Local anesthesia is usually necessary in class V cavity for painless handling of hard and soft tissues and to decrease salivation. Any debris, calculus or plaque should be removed completely to assess the complete extent of the lesion. While choosing the shade of composite material slightly darker shade should be selected as the tooth is darker in the cervical area. Isolation of the site/area is of prime importance when restoring such areas. Isolation is achieved by rubber dam and/or with cotton rolls and retraction cord.

### Tooth Preparation

#### Conventional Class V and VII Preparation

Conventional class V cavity is prepared if it is completely or mostly located on root surface. If the lesion is partly on crown and partly on root, then the enamel margin is prepared using beveled conventional or modified preparation design and the root surface lesion is prepared in conventional form.

When the lesion is entirely on root surface, a “box” type of preparation is indicated. A tapered bur fissure (No. 700, or 701) is used to make entry at 45 degrees angle to tooth surface, initially with the handpiece tilted distally. Later on, the bur’s long axis is made perpendicular to the external surface in order to get a cavosurface angle of 90 degrees. During this initial tooth preparation, the axial depth is kept at 0.75 mm into the dentin. After obtaining the desired distal extension, the bur is moved mesially, incisally (occlusally) and gingivally for extending the preparation on to sound tooth surface while maintaining a cavosurface margin of 90 degrees. At this point, the axial wall should still be 0.75 mm in dentin and should follow the contour of facial surface incisogingivally and mesiodistally. During the final tooth preparation, any remaining infected dentin, remaining material is removed from axial wall using spoon excavator or small bur. A calcium hydroxide liner is placed, if necessary. If additional retention is required, retention grooves can be placed all along the whole length of inciso-axial and gingivo-axial line angles

using a No. 1/4 or 1/2 flat fissure bur. These grooves are 0.25 mm deep into the dentin. At this stage, all the external walls appear outwardly divergent. Thereafter, the prepared cavity is cleaned (Fig. 25.12).

### BEVELED CONVENTIONAL CLASSES V AND VII PREPARATIONS

Beveled conventional classes V and VII tooth preparations are indicated for (1) replacing defective existing restoration, or (2) restoring a large, new carious lesion. The outline form is prepared in enamel using the same principle as used in class III beveled conventional preparation. The initial axial wall depth should be only 0.25 mm into the dentin, when retention grooves are not placed. The initial axial depth should be 0.5 mm below DEJ when a retention groove is placed. Remove any remaining infected dentin or/and restorative material and apply a calcium hydroxide liner, if needed. Usually, a gingival retention groove is prepared. Finally, bevel the enamel margins at an angle of 45 degrees to the external surface and to a width of 0.25 to 0.5 mm.

Advantages of beveled preparation: Beveled conventional tooth preparation has the following advantages over unbeveled. Beveling provides enhanced surface for bonding hence provides (a) increased retention, (b) decreased microleakage, and (c) conservation of tooth structure, as groove for additional retention can be avoided. When the class V carious lesion is large enough to extend onto the root surface, the gingival part is prepared in the same manner as a conventional class V tooth preparation with the initial axial depth of 0.75 mm. Beveling is done only on enamel cavosurface margins.

### MODIFIED (CONSERVATIVE) CLASS V TOOTH PREPARATION

This type of class V design is indicated for the restoration of small and moderate lesions and defects. Class V modified preparations are ideal for small enamel defects or cavity defects like decalcified and hypoplastic areas located in cervical third of the teeth. Principles and objectives of such type of preparation have been discussed previously. The final tooth preparation should appear 'scooped out' with widely divergent walls, with the axial surface either in enamel or dentin.

### CLASS V AND VII PREPARATIONS FOR ERODED AND ABRADED LESIONS

Abrasion usually appears in the form of a 'V' shaped notch caused due to wearing away of tooth structure due to mechanical forces like vigorous improper tooth brushing or abrasive toothpowder or paste. Erosion usually appears as a saucer-shaped notch which occurs primarily as a result of chemical dissolution. Such areas may exhibit caries, plaque accumulation, gingival recession and sensitivity and may appear ugly. For these reasons, these areas should be restored. The tooth preparation for classes V and VII abrasion or erosion area requires only roughening of internal walls, beveling or flaring all enamel margins. In class V, sometimes, placing retention groove in non-enamel areas is required. Greater retention to class V restoration is provided with a groove form.

Besides typical classes V and VII preparation for eroded and abraded areas, several more conservative procedures are also available. All these methods depend on bonding for retention of restorative material. These methods include the following:

- The 'sandwich technic' in which a glass ionomer cement is used to line the dentin for adhesion and then a cosmetic resin is bonded to this cement and over this cement to the etched enamel.
- Use of acid etching in order to bond a restorative resin, without cavity preparation. Usually, light-cured microfill composites are used.

### TOOTH PREPARATION FOR PIT-LIKE FAULTS OF SMOOTH SURFACES

Most pit faults in enamel are restored best by employing modified preparation. The outline form is dictated by the extent of the fault and carious lesion. The enamel margin is flared and beveled.

Such type of classes V and VII preparations for abraded/eroded/pit faults are called '*non-mortise saucer-shaped preparation*'.

### Restorative Technique

Small class V restoration can be contoured without matrix in unpolymerized state.

- Etching, priming and placing adhesive:* These procedures and technique are same and have been discussed previously.

- b. *Inserting and curing the composite:* A self-cured or light-cured composite can be inserted by hand instrument or syringe. In restoring classes V and VII lesions, mostly light-cured microfill composites are used. Their main advantages are that they are esthetically acceptable smooth and can resist cervical flexure. No matrix is used for restorations of classes V and VII lesions. The excess material should be removed first from the gingival cavosurface margin with the side of the tip of no. 2 explorer.

For abraded and eroded lesions, the retentive undercut, if present, should be filled first and cured. Subsequent increments should be made over it and cured to achieve the shape and contour of restoration similar to natural tooth contour. Excess material should be removed with the side of the tip of a fine explorer.

- c. *Contouring and polishing:* It should be done approximately after 3 minutes of initial hardening of the material. Contouring and polishing is done using pear, inverted pear and flame-shaped finishing and polishing diamond instruments at medium speed with light strokes and air coolant. Final finishing and polishing are achieved with a rubber-polishing point and aluminum oxide polishing paste. A fine grit abrasive disk at low speed can also be used for polishing flat surfaces like proximal surfaces of incisors.

## REPAIR OF COMPOSITE RESTORATIONS

A localized defect in composite restoration in an easily accessible area should be roughened with a diamond stone and the enamel margins are etched. Then primer and/or adhesive is applied as per directions of the manufacturer and finally composite is inserted, avoiding any void, contoured, cured, and then finished and polished. In inaccessible areas and in the areas that are difficult to access, damaged area should be exposed by tooth preparation, matrix is placed, enamel margins are etched, primer and/or adhesive applied and then the composite is inserted avoiding any void, contoured, cured, and then finished and polished. In case a void is present, more composite can be added to the area, before any contouring is done. If the void is detected after contouring, then the area is etched, primer and adhesive are applied, and then the composite is added and cured.

## GLAZING

### Improving Surface Smoothness of Composite Restoration

The surface smoothness and shine of a composite restoration can be temporarily increased by a process called “glazing”. In this technique, the composite resin surface, after contouring and finishing, is cleaned and dried and then painted with an activated or inactivated resin monomer (continuous phase). This is then light cured. The resultant surface is initially very smooth and shiny but only for about few weeks. Gradually, the surface is abraded away during function, as it lacks the abrasive resistance and adhesion. To improve the adhesion of these glazes, the restoration surface should be etched by low concentration of hydrofluoric acid, prior to glazing. Glazing is not used on silicate and ASPA restoration and is not required over unfilled resin restorations.

### Pulp Protection when using Composite Resin

While making a cavity or tooth preparation for restoration with composite resins, the following are kept in consideration:

- No pulp protection is needed in type (a) and (b) cavities (see Figs 8.54A and B).
- In type (c) cavities indirect pulp capping is done (see Fig. 8.54E).
- In type (d) cavities direct pulp capping is done (see Fig. 8.54D).
- Zinc oxide eugenol should not be used as a sub-base because it inhibits the polymerization of resins.
- If the intermediary basing has been applied, then all dentinal walls and floors should be covered with powdered calcium hydroxide, before any etching is carried out. This calcium hydroxide should be removed after etching.

## GLASS IONOMER CEMENTS (GIC)

It was introduced in mid-seventies by Mc Lain, Wilson and Kent. It combines the advantages of silicates, composite resins and polycarboxylate cements. As the name implies, the powder is a glass and the setting reaction and the adhesive bonding to the tooth structure involves ionic bonds. It is a hybrid material, partly organic and partly inorganic and is formed by the reaction of an ion leachable glass with aqueous solution of polyacrylic acid. It is often referred as poly (alkenoate) cement or

ASPA (aluminosilicate polyacrylic acid). Those GICs that are designed as luting agents, liners and bases are classified as conventional type I. Restorative formulations are type II, whereas light = cured GIC used as liners and base are generally listed as type III. Type IV hybrid-resin modified glass ionomer is used for esthetic fillings with conservative cavities avoiding stress-bearing areas. The conventional type II GIC, used for restorative purposes, is supplied as a powder-liquid system in which the powder contains acid-soluble calcium-fluoroaluminosilicate glass with a higher alumina/silica ratio as compared to silicates. Fluorides of calcium, sodium and aluminum are present as fluxes. The liquid contains polyacrylic acid in the form of a co-polymer with itaconic, maleic, or tricarboxylic acid. Tartaric acid is also present in the liquid.

### **Advantages**

1. Esthetically reasonably acceptable.
2. True chemical bonding with tooth structure takes place.
3. Long-lasting release of fluoride which exhibits anticariogenic properties.
4. Biocompatible.
5. Conservation of tooth structure is possible.
6. Coefficient of thermal expansion is close to enamel.
7. Provide good insulation hence insulator base is not required.
8. Less soluble than silicates.
9. Less irritating to pulp than silicates and composites.
10. Exhibit least microleakage than other tooth-colored restorative materials.

### **Disadvantages**

1. Technique sensitive.
2. Lack fracture toughness.
3. Low wear resistance.
4. Low compressive strength and hardness as compared to silicates.
5. Sensitive to water content in liquid and in dry environment and are prone to dehydration and cracking if not protected.
6. Cannot be finished at the time of placement.
7. Esthetically not as good as composite materials.

### **Indications**

Conventional type II GICs are used in the following conditions:

1. Class III cavity restorations.
2. Class V and class VII cavity restorations where esthetic is not a major consideration.
3. Class V root surface caries in aged patients.
4. In patients with high caries susceptibility indices.
5. 'Slot' like preparation in class II or III cervical locations not involving proximal contacts.
6. Where life expectancy of the tooth is not more than three years.

### **Contraindications**

1. Classes I, II, IV and VI preparations which are under heavy occlusal forces.
2. Areas in which a dry field cannot be achieved. (For details on glass ionomer cement refer to chapter 27 and textbook of dental materials with MCQs by the authors).

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## 258 *Textbook of Operative Dentistry*

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# 26

## *Direct Composite Restorations for Classes I, II and VI Cavity Preparations*

With the improvements in the composites they can be used for the restoration of classes I, II and VI cavity preparations in selected cases where esthetics is more important.

### **CLASSES I, II AND VI CAVITY PREPARATIONS FOR DIRECT COMPOSITES**

*Basic preparation design:* Depending on the extent of cavity to be restored there are, three designs preparations (1) conventional, (2) beveled conventional, and (3) modified (conservative).

#### **Conventional Design Preparation**

These box-like cavities slightly converge towards the occlusal walls, have flat floors and undercuts in dentin for retention. As a bonded cavity, restoration has capacity to strengthen the tooth, conventional type of preparation may be used with posterior composite for classes I, II and VI cavities. When the class II cavities extend onto the root, design of the cavity preparation of root portion should also be conventional.

#### **Beveled Conventional Design Preparation**

For composite restorations, cavosurface bevel is recommended, because more surface area is provided for bonding and more preferred end-on etching of enamel rods can be done. This increases the retention and there is greater strengthening of the remaining tooth structures. Beveling is done with coarse flame-shaped diamond burs. The placement of the bevels is determined by the direction of enamel rods. Due to the configuration of enamel rods on the occlusal surface, the occlusal bevels are less beneficial and to avoid occlusal forces, are not included in the cavity preparations (Figs 8.55 and 26.1A and B).

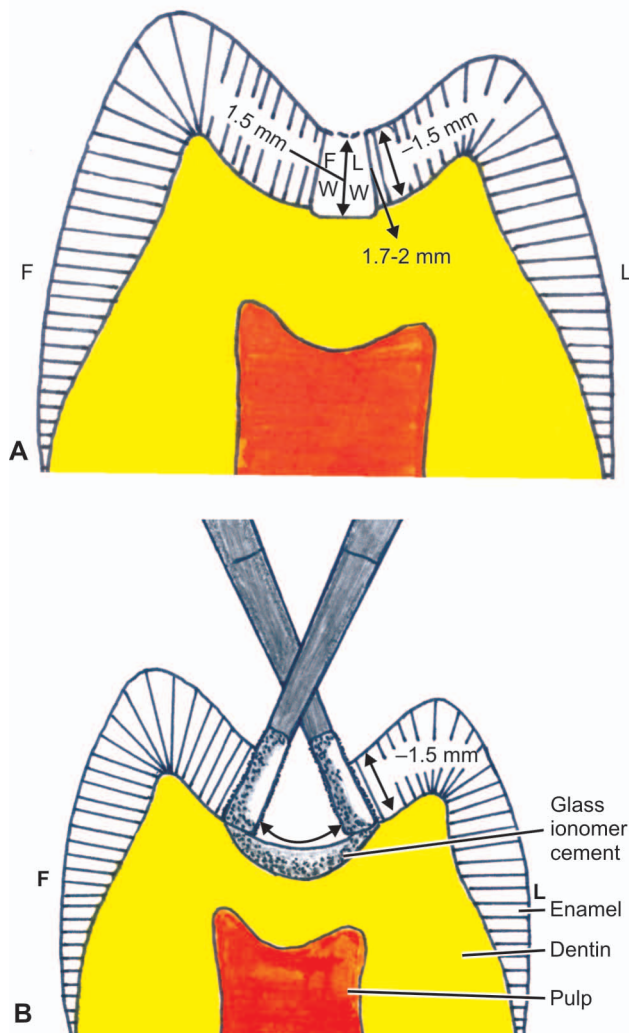
Beveled conventional design is more suitable for small class II cavities and less suitable for class I and class VI cavities. Class II restoration experiences greater incidence of proximal failure due to fracture and dislodgment of the proximal portion. The beveled conventional preparation should be prepared with as little faciolingual extension as possible and should not routinely be extended in pits and fissures on the occlusal surface.

#### **Modified (Conservative) Preparation Design**

Modified cavity design for composite is typically decided by the extent of defect/damage in which intact tooth structures are as much conserved as possible (Fig. 26.2).

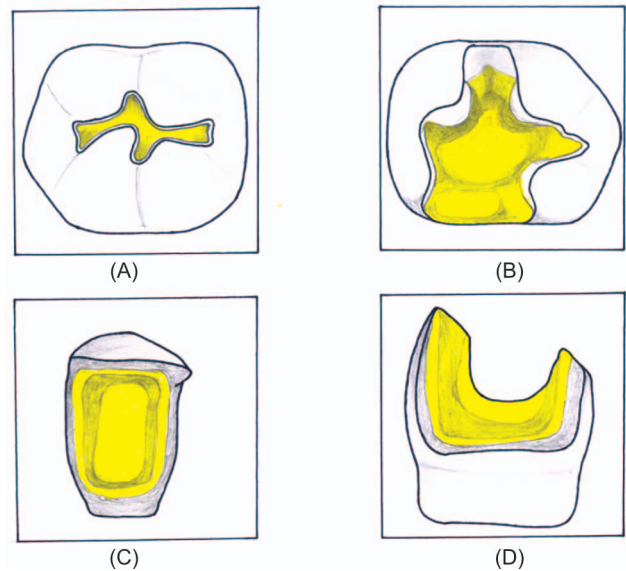
1. Class I restoration
  - A. Class I cavity for moderate caries
  - B. Class I cavity for extensive caries: Only carious dentin and enamel has been removed. Some undermined enamel is preserved, which will be supported by the posterior composite material
2. Class II MOD extensive caries in maxillary second premolar (C) Occlusal view (D) Mesial view (Distal view is also like mesial). To enhance the resistance and retention form reverse bevel, secondary flares and brace-type 'skirting' have been done.

Modified cavity preparations are usually characterized by (a) less specific in form, (b) have scooped out appearance, (c) conservative removal of carious lesions, and (d) establishing the beveled cavosurface margins. In typical cavosurface bevel, additional beveling extends the marginal outline conservatively including the nearby deep pits and fissures. For more extensive caries, cavity design for class I and class II cavities can develop unique preparations, such as reverse bevels, secondary flares and skirting on the axial surface to improve the retention. To conserve the tooth tissue undermined preparations can be made wherever enamel has sufficient thickness of dentin to support it.



**Fig. 26.1:** (A) Class I preparation for direct composite initial pulpal depth. Facial (FW) and lingual (LW) walls are usually greater than 1.5 mm which is the depth of preparation in the center. The steeper the wall, the greater the height. Depth of central groove (1.5 mm). Facial and lingual wall height is approximately 1.7 to 2 mm (F- Facial surface L- Lingual surface), (B) Class I direct composite restoration. Bur is tilted facially and lingually to maintain a 1.5 mm depth and to remove carious dentin. Deeper caries is also removed and deeper portion is filled with GIC (F= Facial surface L= Lingual surface)

These types of cavity designs are recommended in class I and class VI cavity, where the conservative preparation can be made. They are prepared by small round or inverted cone with round corners bur. Initial pulpal depth is 1.5 mm or about 0.2 mm inside DEJ.



**Fig. 26.2:** Modified (conservative) cavity preparation for posterior composite restoration

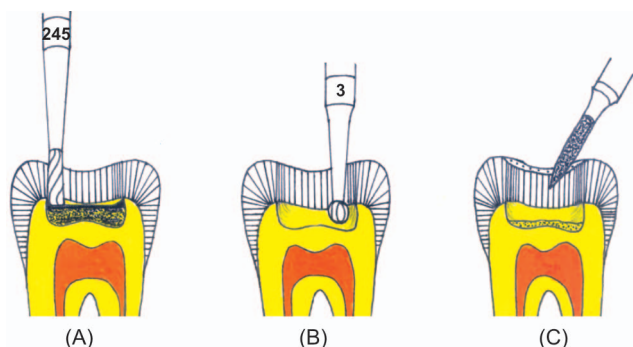
1. Class I restoration
  - a. Class I cavity for moderate caries
  - b. Class I cavity for extensive caries—only carious dentin and enamel has been removed. Some undermined enamel is preserved, which will be supported by the posterior composite material
2. Class II MOD extensive caries in maxillary second premolar (C) Occlusal view (D) Mesial view (Distal view is also like mesial). To enhance the resistance and retention form reverse bevel, secondary flares and brace-type 'skirting' has been done

The depth may not be uniform and pulpal floor may not be flat.

## CLASS I CAVITY PREPARATION

In small pit and fissure defects conservative modified preparations are recommended. An ultraconservative restoration is referred to as '*conservative composite restoration*'. This general concept was developed and reported basically in 1978 by Simonsen and also referred to as '*preventive resin restorations*'. In the conservative composite restoration, a diagnosis of carious cavity has been made prior to cavity preparation, whereas the preventive resin restoration may precede a possible diagnosis of cavitation. Composite should not be used if surface cannot be properly isolated and in increased

wear areas on occlusal surface. In molars, occlusion must be evaluated before preparation is started because centric holding areas are mostly involved (Fig. 26.3).



**Fig. 26.3:** Large class I cavity preparation for composite restoration (A) For initial cavity preparation a No. 245 bur is used, (B) For removal of the remaining caries a round bur is used, (C) Preparation is completed by beveling of margins with diamond bur

Rounded corners inverted cone burs are preferred in preparation of modified cavity preparation for the following reasons:

1. They prepare wall which converge occlusally increasing retention
2. They prepare rounded line angles.
3. They provide flat floor increasing retention and resistance.
4. They provide occlusal marginal configuration thereby strongest enamel margins.
5. They produce faciolingually more conservative width.

The enamel cavosurface margins are beveled with flame-shaped diamond instruments. Beveling may be considered optional if radiating fissures are not included in preparation of occlusal surface. After removal of remaining faulty restorative material or caries with round bur/spoon excavators, a liner of calcium hydroxide and/or light-cured glass ionomer is placed depending on the depth of excavation. When a marginal ridge is not supported by dentin, remaining weakened enamel may be left if there is no heavy centric contact on this area. The unsupported marginal ridge will be strengthened by composite restoration due to beveling, etching and bonding procedures between tooth surface and restoration.

The preventive resin restoration of fissure may be considered, the initial enamel depth is kept as 1 mm.

The preparation is completed by using a flame-shaped diamond bur to prepare a bevel on cavosurface margin, nearly 45 degrees to the external enamel surface. This beveling may be widened to include any terminal end of fissures.

The outline form and clinical procedures for cavity preparation of each pit are similar to modified Class VI cavity preparation with the possible exception of beveling. Normally, cavosurface bevel is 0.5 mm wide and placed at an angle of 45 degrees to the external enamel surface. This extended bevel is similar to enameloplasty (Fig. 26.4).



**Fig. 26.4:** Modified cavity preparation. Conservative cavities for extensive caries in first and second mandibular molar—restored with direct composite material

### Occlu Print

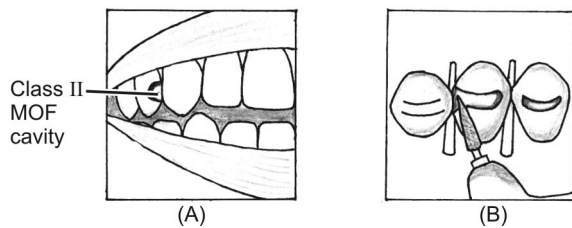
This is a stamp for design of occlusal surface of posterior teeth. Before curing the last layer of composite, after placing the material 'occlu print' stamp is pressed. It creates an accurate and esthetically correct design of occlusal surface. It is available in different shapes and designs for all molars and premolars (upper and lower and left and right side). For easy identification, the tooth number is printed on each stamp. It is simple and easy to use on all occlusal surfaces. After design of occlusal surface is created by occlu print, the composite material is flushed with cavity margins and cured.

### CLASS II CAVITY PREPARATION

Composites may be used successfully in Class II cavity restorations when done properly. Same factors as in class I may be considered when using composites for Class II



restorations. The advantages are (a) better esthetics, (b) conservation of tooth structure, (c) strengthening of remaining tooth structure and (d) bonding of tooth by composite. The limiting factors for these restorations are (a) inability to isolate the areas, (b) deep subgingival extensions, (c) heavy occlusal contact on the composites which have poor compressive strength (Fig. 26.5).



**Fig. 26.5:** Class II MOF cavity in maxillary first premolar (A) Which is visible (B) Preparation is completed by beveling cavosurface margin with diamond flame-shaped bur

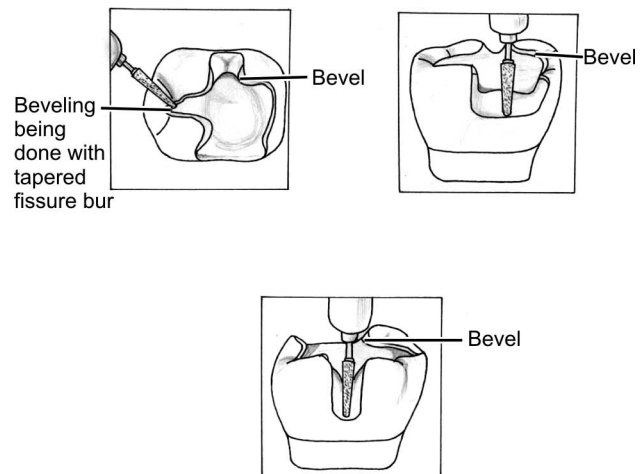
Wedge is placed gingivally in the proximal region. Wedge is placed before the cavity preparation. It helps to separate the contacts and compensates for thickness of band matrix. Conventional conservative cavity is recommended for most of the class II composite restorations. The decreased pulpal depth of axial wall allows greater conservation of tooth structures, so the retention groove will not be used. The occlusal and proximal walls converge occlusally and provide additional retention form.

With spoon excavator, remove any remaining infected dentin. Apply a protective base/liner depending on the depth of excavations. The beveled conventional preparation are completed by placing bevel on proximal and occlusal cavosurface margins. Bevels on occlusal surface are optional due to direction of enamel rods whereas on proximal surface, beveling must be done judiciously. Posterior teeth can be restored with composite materials, but molars with extensive occlusal and proximal involvement are best restored with amalgam, cast gold alloys or ceramic restorations.

## EXTENSIVE CLASS I AND II COMPOSITE RESTORATIONS

The composite restoration has many disadvantages when extensive carious lesions are present. In such cases, large posterior composite sometimes can be used as an alternative when no permanent option is possible. Patients must be informed all the possible limitations of

composite restorations. In extensive caries, conservative cavity (undercuts) with increased bevel width for extensive bonding may assist in retention of materials and provide strength to remaining weakened tooth structures (Fig. 26.6).



**Fig. 26.6:** Extensions and bevels in extensive class I preparation (A) Occlusal view, (B) Lingual view, (C) Buccal view

First molar erupting at an early age are sometimes neglected and develop an extensive caries. When infected dentin is removed, weakened tooth with unsupported enamel may remain. In such cases, the posterior composite materials provide strength to the remaining tooth structure. Soft carious enamel and dentin is removed. Facial and lingual conservative extensions are made with a coarse round bur, the width and length of extension depending upon the size of tooth and area of defects. After final cavity preparation is completed, properly etched and restored, the composite materials act as splint to bond and lock the tooth together with the restoration. The esthetics and bonding with tooth structures requiring conservative cavity are the main factors replacing the amalgam with composite restorations. But the patients should be instructed that the composite restorations may need replacement in a few years if restorations are placed in excessive wear areas or inadequate bonding occurs.

## CLASS VI CAVITY PREPARATION

Posterior composite restoration is indicated for very conservative preparation in a small damage or defect on a cusp tip. Tooth is isolated with cotton rolls, cavity preparation should be small in diameter. Enter with

the round bur, keeping it perpendicular to the surface extending in pulpal floor to eliminate the caries. Remove caries with round margin inverted cone bur.

Complete the preparation using coarse flame-shaped or round diamond bur to prepare small bevel on cavosurface margins. Any stain that appears through the translucent enamel must be removed.

### Protection of Pulp

If composite restorations are properly done in which walls and margins of preparations attain adequate bonding, the microleakage may not occur hence, no need for liner or base. Calcium hydroxide base is indicated to treat the pulp near to exposure. If bonding is questionable, there is potential of microleakage such as when deep gingival proximal box exist with no enamel along the gingival floor.

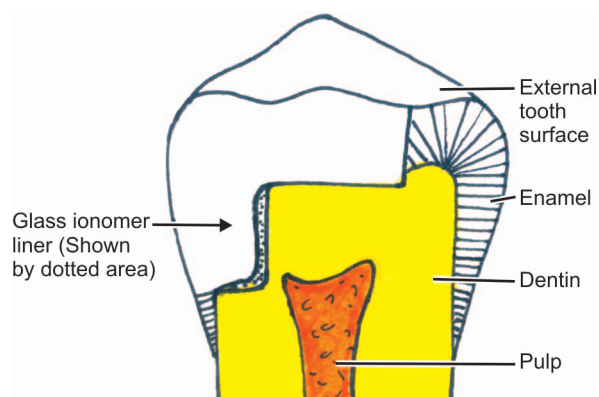
When indicated, a glass ionomer liner/base is applied to provide an anticariogenic effect from fluoride release. In proximal cavities, isolation is more difficult and these enhance the microleakage; in such cases, glass ionomer cement must be placed on gingival floor and entire axial wall. It may offer protection from recurrent caries (Fig. 26.7).

### INSERTION OF COMPOSITE IN CAVITY INVOLVING PROXIMAL SURFACE

The most important steps in posterior composite restorations are selection and placement of matrix.

Like amalgam restorations, posterior composites are dependent on contour and position of matrix for producing adequate proximal contacts. Early and adequate wedging is done before cavity preparation thereby, achieving the sufficient separation of teeth to compensate for the thickness of matrix band.

A thin matrix band is preferred for composite restoration. In light cure procedures, enamel/dentin bonding is placed over the entire preparation with brush and polymerized with light cure. In composite restorations, the material is placed in small increments and cured successively (small part of material cured with visible light before placing another part of material). The importance of using small increments and curing is to reduce the effect of polymerization shrinkage, especially along with the gingival floor. So in first few increments, very small composite material is used. The restoration



**Fig. 26.7:** Class II cavity preparation with thin enamel along gingival floor with deep gingival margin. Glass ionomer liner is placed on axial and gingival wall to prevent recurrent caries and protect pulp

can be contoured immediately after the last increment of composite is placed. 'Occluprint' can be used in posteriors. After curing, finishing is done. If a light cure composite is not available, then self-cure composite may be used.

### Finishing of Composite Restorations

After curing, the occlusal surface is shaped with round carbide finishing burs and excess material is removed at the proximal margins with flame-shaped carbide burs. The essential contour of larger restoration involving the facial or lingual surface is established with diamond burs. Diamond instruments are very effective for contouring and finishing of all resin systems. In gingival proximal surfaces, narrow finishing strips are used to smoothen the surface. If excess material is removed, occlusion is evaluated in centric position and during various mandibular movements for proper contacts. If occlusion is not proper further adjustments are made and restorations are finished with fine rubber abrasive points or discs.

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The glass ionomer cement (GIC) was developed by Wilson and Kent in the year 1972 in England. The International organization for Standardization (ISO) terminology named it as Polyalkenoate cement or Alumino silicate polyacrylic cement (ASPA). GIC is basically a salt formed by the reaction between polyalkenoic acid and calcium alumino-fluoro-silicate glass. This cement is extensively used to replace dentin, hence it is also referred as 'artificial dentin'; 'dentin substitute' and 'man made dentin'.

### Composition

**Powder:** It is referred as an ion leachable glass, consists of aluminosilicate containing calcium and fluoride.

**Liquid:** It is essentially 50 percent of polyacrylic acid.

Various types of GIC are created by altering the particle size or varying the form of the liquid components.

### GENERAL PROPERTIES

1. Esthetically acceptable as anterior restorative material and also as luting cement. It has lesser film thickness than zinc phosphate cement.
2. Anticariogenic property due to continuous fluoride release.
3. True chemical bonding to both enamel and dentin, apart from bonding to steel, gold alloy plated platinum and tin oxide.
4. Comparatively biocompatible and less irritating to pulp than silicates.
5. Coefficient of thermal expansion is almost similar to tooth structure, particularly to dentin.
6. Dimensionally stable.
7. Insoluble in oral fluids at intraoral temperatures.
8. Conservative tooth preparation is required.
9. Restorations can be easily replaced and repaired.
10. Good color and shade range with translucency is available.

### TYPES OF GLASS IONOMER CEMENTS

There are mainly five types of GIC.

#### Type I

##### Conventional

Type I is used as cements, liners and bases.

Its properties are as follows:

- a. Powder particle size is reduced to 15 micron or less.
- b. It is modified by adding co-monomer to polyacrylic acid.
- c. Thin pulpal dentin is required to be protected with hard setting calcium hydroxide.
- d. Working time is usually 4 to 8 minutes.
- e. Thickness of cement film is 25 microns or less.
- f. After 24 hours it usually becomes insoluble with compressive strength of 68.7 MPa.

#### Type II

##### Restorative

Type II is used in restorations, liners, bases and cores.

They are of following two types:

**Class I:** Esthetic restorative cement. It is mostly used for anterior teeth

**Class II:** Reinforced restorative cement or metal modified GIC: It is mostly used for posterior teeth as restorative material, bases and cores, hence they are also called 'posterior glass ionomer'. They are subclassified as follows:

- i. Amalgam alloys mixed with cement, i.e. Ag-Sn or Ag-Pd admixed with silver alloy admix. Its example is miracle mixtures or miraclemix Ag-Pd has greater adhesive property than that of Ag-Sn.
- ii. Ceramic metal mixtures its example is cermet. In this glass powder is fused and sintered with silver particles.

Properties of type II class 2 GIC are as follows:

- a. More resistance to wear as they are stronger and tougher.



## 266 Textbook of Operative Dentistry

- b. Less pulpal irritation..
- c. Lesser fluoride release than type I.
- d. Poor esthetics due to metallic color.

### Type III

#### Light Cured Glass Ionomer Cements

Type III is used as liners and bases. It is available in powder and liquid form.

1. *Powder*: Powder consists of ion leachable glass with other powder particles also mixed with aluminosilicate glass. In case of dual cure GIC initiators are present for light or chemical curing. Both light and chemical curing initiators are present in case of tricure GIC.
2. *Liquid*: Dentin bonding agents such as HEMA (Hydroxy Ethyl Methacrylate ) is added to liquid component. To reduce overall shrinkage and increase flexural toughness, monomers in liquid are modified with acrylic functional groups.
3. *Setting*: Reaction is initiated by polymerization of methacrylate group and final strength is achieved by the completion of slow acid-base reaction.

Properties of type III G.I.C are as follows

- a. Stronger adhesion to tooth structure than those of conventional GIC.
- b. Increased tensile strength due to the presence of resin by sustaining fracture.
- c. Reduced translucency
- d. Great reduction in water dehydration and absorption.
- e. Reduced marginal adaptation and more micro-leakage due to polymerization shrinkage.

### Type IV

*Hybrid Resin*: modified Glass Ionomer Cements

Type IV GIC are used for cores restorative filling material.

1. *Powder*:
  - To reduce total shrinkage and to improve strength, polymers and other phases are added to powder component.
  - Composites are blended with tiny beads of precured glass ionomer.
  - To increase fluoride release, some part of powder is substituted with silicate glass of composites. It consists of 80 percent GIC and 20 percent visible light hardened resin component.

2. *Liquid*: HEMA and other monomers are added to liquid component for bonding.

### Properties

- a. They have higher resistance to wear, tear and fractures, and are more strong and tough.
- b. Esthetics of finished fillings is similar to that of composites. Hence recommended for classes I, II, V and VII fillings with conservative cavity preparation avoiding stress bearing areas and also in all types of cavities of deciduous teeth.

### Types V

*Polyacid*: modified resin composite OR glass ionomer resin composite (Compomer) (abbreviation CM)

It is used as cements, restorative filling materials and cores. Its example is Dyract of Dentsply Co. In order to improve poor early strength and moisture sensitivity of GIC, due to slow acid-base setting reaction, chemically curing or light curing resins have been added.

1. *Powder*: consists of an ion leachable glass as in a conventional GIC. Initiators are present for light or chemical curing or both for light cured GIC, dual cured GIC or tricured GIC.
2. *Liquid*: consists of methacrylate monomers with multiple carboxylic groups.

The mechanical properties are superior to those of conventional and resin-modified GIC (RMGI) and at times equal to contemporary polymer-based composites.

## USES OF GLASS IONOMER CEMENT

GIC is used as follows:

1. Cementing or luting Agent—for inlays and onlays (both metallic and non metallic), crowns, pins and posts, veneers, orthodontic bands and brackets.
2. Restorations of a permanent — class III, V and VII cavities
  - Root caries
  - All classes of cavities in geriatric patients
  - All classes of cavities where life expectancy of the tooth is not more than three years.

- All classes of cavities in uncooperative patients.
- Abrasion/Erosion lesions
- b. Deciduous teeth — all classes of cavities and rampant caries
- c. Other restorative techniques — Sandwich technic (bilayered/laminated restoration),  
— Bonded Restorations  
— Atraumatic Restorative Treatment (ART) (for ART Fuji VIII and Fuji. IX are suitable)
- 3. Pit and fissure sealant.
- 4. Dentin substitute, as cement base/liner under composite and amalgam.
- 5. In endodontics
  - GIC is used as sealer
  - GIC is for repairing perforations.
  - GIC is for repairing external root resorption
- 6. For core build up
- 7. Glazing over GIC is done— for protecting new GIC
  - glazing traditional GIC
  - improving esthetics of old GIC filling.

GIC is most suited for hidden class III and large class V cavities.

For atraumatic restorative treatment (ART) a high strength GIC is also used.

## MAIN ADVANTAGES OF GIC

1. Chemical adhesion with enamel and dentin.
2. Esthetically matches the tooth color and shade.
3. Prevention of dental caries due to a slow and continuous release of fluoride.
4. Bacteriostatic and bactericidal properties.

## MAIN DISADVANTAGES OF SELF-CURING GIC

1. Poor wear resistance.
2. Lower resistance to fracture
3. Longer period for hardening is required
4. Poor toughness.

### Class III Cavities

GIC is the material of choice for class III cavities extending onto root surface. In class III cavity as far as possible access is gained from the lingual side to make it caries free without cutting the labial surface as far as possible. The external outline form is similar to the conservative class III design for composites. Initial carious lesion, demineralized enamel or any previously placed restorations are removed. Margins have a butt-joint configuration owing to brittle nature of GIC. Small retentive grooves placed incisally and cervically provide additional retention. In contrast to resins, etching is not required in GIC. To minimize esthetic problems, a lingual approach is used. This also reduces dehydration of GIC.

### Classes V and VII Cavities

Classes V and VII carious lesions are usually seen in patients with high- caries risk. Classes V and VII non-carious damage is usually due to abrasion and erosion. In class V the lesion may be only in enamel or enamel and cementum. Class VII cavity may be in enamel. Both classes V and VII cavities may involve dentin also. External outline form is guided by the extent of the lesion and previous restoration. Rounded grooves placed in occlusal and cervical dentin wall provide additional mechanical retention. If the lesion extends onto the cementum, GIC effectively reduces microleakage at the tooth-restoration interface.

### Cervical Abrasion or Erosion

If rough eroded surface is present and as tooth structure has been already lost, usually no further extensive 'preparation' is made. Retention is obtained partly from rough surface by mechanical means and partly by chemical chelation. When margins are placed on cementum, usually no further removal of tooth structure is done. GIC is placed directly onto clean, untreated dentin. When abrasion or erosion lesion margin is surrounded by enamel, composite resin is preferred

## 268 Textbook of Operative Dentistry

due to its bonding capability to enamel, superior esthetics and surface finish (Fig. 27.1)



**Fig. 27.1:** Cervical abrasion due to wrong tooth brushing (shown by arrows)

### PROCEDURAL STEPS FOR RESTORATION OF GIC

#### Cavity Preparation for Glass Ionomer Restorations

Although Black's principles of cavity preparation should be followed for GIC; but due to their adhesive and fluoride releasing properties, these principles can be relaxed upto some extent.

#### Isolation and Moisture Control

Since GIC is sensitive to water, isolation from saliva, sulcular fluid and gingival bleeding is essential for success of GIC restoration. For isolation rubberdam, retraction cord, cotton rolls and saliva ejectors are used. Double tip saliva ejector, in which one tip remains on lingual side and other tip on the facial side is more effective.

#### Tooth Preparation

It is done in two steps:

1. Mechanical preparation
2. Conditioning (Chemical preparation).

#### Mechanical Preparation

- A. *Outline form:* Outline form is governed by caries, discoloration and esthetics. As GIC resists caries, the preparation is done very conservatively. The main points are as follows:
- a. If not involved in caries, contact areas are not cut to bring the margins to self cleansing areas.
  - b. The unsupported enamel is not removed if it is not exposed to heavy masticatory forces.
- B. *Retention and resistance form:* The GIC has true or chemical adhesion to enamel and dentin. Hence, excessive, major and undue undercuts and dovetails are not required at the cost of healthy tooth structure. The material should be sufficiently thick in bulk, atleast one mm thick to resist the fracture under masticatory load and two to three mms thick in the areas where masticatory load is heavy.
- C. *Debridement, prophylaxis and isolation:* GIC chemically bonds to the cavity walls, hence the cavity walls must be clean and conditioned.

Pumice slurry is used to remove plaque and pellicle. Thus, prophylaxis helps in cleansing the surfaces after cavity preparation. The dentin surface is conditioned (i.e. smear layer is removed) using polyacrylic acid for 10 to 20 seconds. Areas with less than 0.5 mm thickness of remaining dentin are covered with hard-setting calcium hydroxide liner. All debris, plaque and pellicle must be removed. For this purpose, pumice slurry on rubber cone, cup, bristle brush or Burlew's brush disk or cone are used. Bleeding from gingival margin must be stopped by pressure pack, or by application of tincture ferric per chlor or trichloro acetic acid.

Tooth surfaces to receive GIC should be absolutely clean and free of contaminants such as debris and saliva. For class V cervical erosions, class VII and other surfaces, where cutting of tooth structure is not planned; clean the surfaces with a non-oily, non-fluoridated prophy paste containing pumice. Thoroughly rinse with water, and dry the surfaces with oil-free air. Do not use fluoridated prophy pastes containing glycerin, which inhibits the chemical bonding of GIC to tooth structure. After cutting thoroughly rinse the debris off the cut surfaces with water, and dry with oil-free air.

#### CHEMICAL PREPARATION (CONDITIONING)

After proper prophylaxis the tooth (cavity) preparation surface is chemically prepared to condition for better

bonding. Polyacrylic acid 10 to 20 percent is applied for 10 to 20 seconds which produces best conditioning.

This provides best adhesion. Other conditioning agents which give variable results are EDTA (10%), citric acid 50 percent, tannic acid 25 percent.

### Priming the Tooth Surface

After conditioning the priming is only done for light cure glass ionomers. Priming agents are used for 10 to 30 seconds as recommended by the manufacturer.

According to some manufacturers chemical preparation and priming is not essential.

### MIXING OF GLASS IONOMER CEMENT

Mixing should be done using the powder: liquid ratio as recommended by the manufacturer. Mixing should be done (a) at room temperature 70 to 77 degree F (21 to 25°C) (b) Humidity of 40 to 60 percent (c) for 45 to 60 seconds (d) on a cool (not below the dew point) and dry glass slab or paper pad and (e) with the help of a flat and firm plastic spatula. Capsule dispensing is popular for type II restorative GIC. Mixing must be done carefully. Glass slab is better than paper pad for mixing as it can be cooled to prolong the working time if required. The mixing is done to wet powder particles and like filler particles in composite the core of every particle remained unreacted. Spatulation is done gently.

*Working time:* Working time is one to one and a half minutes for GIC and three minutes for resin modified GIC. Loss of gloss on the surface of the mixed cement shows end of working time and start of setting reaction.

### RESTORATION

After mixing both the chemical cure and light cure cements are carried in one bulk to the cavity. It is adapted into the cavity by gently pressing with spatula or plugger. The filling is contoured and gross excess is quickly removed. It can also be contoured by covering with a pre-shaped and contoured matrix for 5 to 8 minutes. The matrix helps in proper placement of GIC in the cavity and reduces voids and porosities. Filling the GIC in the cavity with the help of a syringe avoids voids in the filling and over filling of the cavity. In any case, the material is not manipulated beyond the point where the surface appears to lose its glossy appearance. The chemical cure

cement is kept pressed with the matrix till it attains initial hardness. The light cure cement is photo activated for at least 60 seconds. It is better to slightly cure the filling for a longer period to avoid deficient light curing due to distance between light and restoration. Overcuring will not adversely affect the properties.

### FINISHING AND POLISHING

The use of matrix produces best finishing. After matrix removal, to prevent water exposure varnish or cocoa butter is applied until initial set is achieved. Then gross excess is trimmed with sharp hand instruments such as BP knife, gold foil knives. Finishing diamond points at very slow speed with petroleum lubricant are used without water coolant. The restoration is finally covered with colorless varnish, light cure resin bonding agent, petroleum jelly or cocoa butter to prevent dehydration.

Final finishing is done after 24 hours; using coarse to fine finishing diamonds points, fine white stones, silicon abrasives impregnated in rubber in various shapes, abrasive strips and aluminium oxide discs. Dry finishing with abrasives will dehydrate the surface and make it porous resulting in early disintegration of the cement. After final finishing again the surface is covered with varnish or resinous glaze materials. If GIC does not come in contact of water for first 24 hours, the cement will mature sufficiently to develop full translucency. Gupta Ruchika and Narayanan L Laxmi observed that the interaction between the glass ionomer and the polishing medium improves the external structure of GI with the best surface texture obtained by using a combination of 'softest' disc and polyacrylic acid for finishing and polishing respectively.

### Protection of Surface

Resins are less permeable, and fill the surface irregularities, and give a smooth surface to GIC rather than varnish, cocoa butter or petroleum jelly. Resins also provide longer and better protection. Resins provide the best surface protection to the cement. They fill the surface irregularities to give smooth finish for longer periods with impermeable surface. Varnish, cocoa butter and petroleum jelly are washed away in shorter periods. Resins provide protection for longer periods. If surface is not protected for first 24 hours, cracks will appear at the surface.



## USES OF GIC

### Restorative Cements

- Cervical margin lesions:* For these lesions, GIC is a good restorative material. Usually, the mechanical retention obtained in cavity preparation is poor. The chemical (ion exchange) adhesion which is essential for retention is superior with GIC.
- Abrasion and erosion with or without caries:* Due to anticariogenic effect and the ability to bear the flexural change in the tooth GIC is most suitable restorative material for abrasion and erosion lesions.
- Abfraction lesions:* Strong eccentric occlusal force result in microfractures or abfractions (associated with wear facets). These occur on cervical areas or cemento-enamel junction of the tooth where tooth flexes under such load. This is also called as 'idiopathic erosion' or 'abfraction'. In these cracks sometimes caries develop. The lesions become longer and deeper, if the forces remain active for a longer period.
- Small cavities:* GIC is indicated in small cavities which are not exposed to heavy masticatory forces, in patients with high caries susceptibility.
- Class III cavities:* Light cure GIC provide better esthetics in class III cavities hence, it is used in such cavities.

### Lining Cements

GIC is used for giving lining under metallic filling and also for filling the undercuts in preparations for inlays and crowns. For lining under composite light cure or type II GIC must be used.

*Sandwich (Double or Bilayered) restorations:* Type II and type III (Light cure) glass ionomer cements are used as cement base.

*Sandwich technique:* Due to better adhesion in erosion lesions, where there is poor retention and also in deep carious lesions, where the thickness of the filling material will be more it is advantageous to replace the lost tooth structure with sandwich technique. In this, the lost dentin is replaced by glass ionomer cement and the superficial layer is replaced by light cure composite, thus glass ionomer cement is sandwiched between the tooth and the composite. The advantages of this technique are as follows:

- In deep carious lesion the etching is avoided to avoid the irritation of pulp.
- It has better strength than if only glass ionomer cement or only composite filling is done as GIC is less rigid and acts as shock absorber under composite.
- Slow and continuous release of fluoride prevents recurrent caries.
- GIC bonds with both tooth structure and the composite thus increasing retention.
- Polymerization shrinkage is reduced as total quantity of composite is reduced.

### Luting

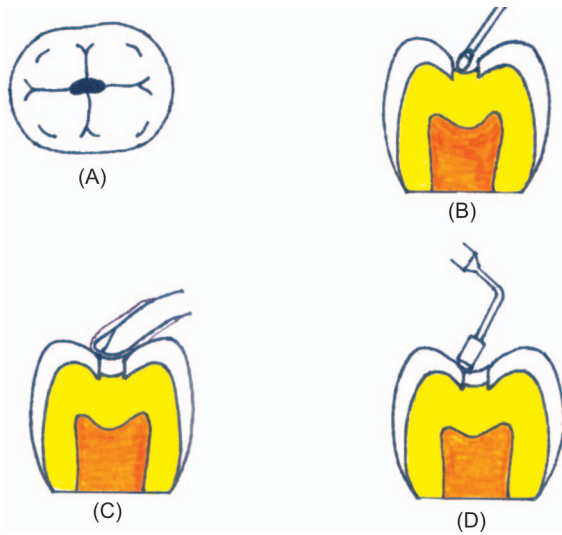
GIC is also used for cementing inlays, crowns, bridges and orthodontic appliances because of the following properties:

- Anticariogenic property
- Thin film thickness
- Sedative to pulp
- Adhesive property.

## ATRAUMATIC RESTORATIVE TREATMENT (ART)

This is an effort to make the fillings cheaper and also available at the door steps of the poor rural masses living in remote areas. Taking the advantages of chemical adhesion and continuous fluoride release the glass ionomer, cement filling is done without proper cavity preparation. Through this technique cavity restoration has reached the poor rural masses who cannot afford to visit cities for costly dental fillings. Continuous fluoride release from GIC helps to prevent dental caries and marginal leakage around fillings.

In this technique, the carious tooth tissue with the help of excavators and hand instruments is removed. Thereafter, the cavity is filled with specially designed resin modified self cured glass ionomer filling material. Suitable GIC for such fillings is GC fuji VIII. This technique is advantageous to patients as it is (a) less costly, (b) less time consuming, and (c) can be used in remote rural areas and also where electricity is not available and as no costly dental instruments and equipment or any devices which are run by electricity are required. It can be done without dental chair, airtor or dental engine etc. (Fig. 27.2)



**Fig. 27.2: Atraumatic restorative treatment (ART)**

- A. Occlusal view of carious lesion in central pit
- B. Undermined enamel is broken off with hand instruments and soft dentin is removed with excavators.
- C. Glass ionomer material is filled in the cavity and any confluent pits and fissures. Restoration is pressed with vaseline coated finger.
- D. Excess is removed and the restoration is finished with hand instruments

The technique involves removal of carious enamel and dentin including undermined enamel and dentin, with hand instruments. After excavating the soft dentin followed by etching and bonding application of glass ionomer cement is done with hand instruments. Hand instruments on the same sitting are used to finish the restorations.

The use of RMGI restorative materials in Class V cavities permits immediate finishing and reduces the rate of microleakage. These materials should be dry finished with abrasive disks to provide a smoother surface without increasing the risk of microleakage. Conventional glass ionomer materials should be wet finished to prevent desiccation.

It has been observed that cavity restoration with Fuji IX has no harmful effects on pulp cells. It adds to the evidence that GIC materials are biocompatible with the pulp.

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## 272 *Textbook of Operative Dentistry*

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## Indirect Tooth-Colored Restorations

Due to improvements in materials and techniques indirect tooth colored restorations have become very popular.

### INDIRECT TOOTH-COLORED INLAYS AND ONLAYS

Tooth colored restorations that are fabricated outside the oral cavity are called as indirect tooth colored restorations. The indirect restorations are made on a replica of a prepared tooth. These systems include laboratory processed composite or ceramic, such as fired porcelain on refractory dies or castable glass. New system CEREC allows indirect computer generated ceramic restorations for rapid delivery of restorations. Usually ceramics are used by indirect method and composites by direct method.

#### Indications

*Large defects:* In classes I and II cavities, mainly in large cavities, especially those that are wide faciolingually and require cusp coverage. The contours of large restoration are more easily developed, and are more durable than direct composites to maintain the occlusal contacts. The ability to resist excessive occlusal wear is especially important in large posterior restorations.

*Esthetics:* By indirect method better esthetics can be achieved.

*Economic factor:* Their cost is more as laboratory expenses are involved. Thus, they are indicated for patients who want best treatment irrespective of the cost.

#### Contraindications

1. Due to heavy occlusal forces ceramic restorations may fracture when they do not have enough thickness or the patient has bruxing or clenching habits. Lack of occlusal enamel or presence of

attrition facets are good indicators of bruxing and clenching habits.

2. Where isolation and dry field is not possible to achieve. (Adhesive technique requires perfect moisture control).
3. Deep subgingival preparations are avoided as their impression taking and finishing is difficult. Bonding to enamel is better hence preferred above the gingival margins.

#### Advantages

Indirect tooth colored restorations have the following advantages:

1. Less chairside time is required, hence it allows more chairside productive time as, auxiliary and laboratory help can be utilized.
2. Proper contacts and contours can be restored.
3. Indirect ceramic restorations are much more wear-resistant than direct composite restorations, especially when restoring the occlusal surface.
4. Indirect technique has reduced the polymerization shrinkage resulting in less stress on restorations, reduced microleakage and postoperative sensitivity.
5. More biocompatible with better tissue response.
6. Strengthens remaining tooth structure. In vigorous carious lesion the remaining tooth structure is weakened and can be strengthened by the adhesive bonding of indirect inlays/onlays.
7. They have improved physical properties. High strength materials have been developed. A wide variety of high strength tooth colored restorative materials, such as laboratory processed composites and ceramics can be used for indirect technique. Indirect restorations have better physical properties than direct restorations.
8. More varieties of materials and better techniques have been developed.
9. Extraoral polishing is easy.



### Disadvantages

Indirect technique has the following disadvantages:

1. It requires patient's subsequent appointment, with need for temporary restoration.
2. Indirect tooth-colored inlays/onlays are more expensive than direct composites.
3. They are highly technic sensitive, restorations requiring high level of operator skill. A devotion to excellence is necessary during tooth preparation, seating and finishing the restorations.
4. Ceramics are brittle in nature, if a preparation does not allow adequate thickness to resist occlusal forces fracture may occur during try-in or after cementation.
5. Ceramics abrade opposing dentition and restorations.
6. Repair is difficult with ceramics.
7. Bonding of indirectly made composite restorations to composite cement is weak. Hence, they require mechanical abrasion and/or chemical treatment for proper adhesion to cement.
8. Less longitudinal studies have been performed and they are less time tested.

### Laboratory Technique of Composite Inlays and Onlays

Composite restorations possess improved physical properties when processed free of contamination and when resin matrix are maximally polymerized. The well cured restoration is best prepared in dental laboratories, that polymerize the composite under pressure, light, heat or vacuum or in combinations. Indirect technic composite inlays/onlays are more resistant to occlusal wear than direct composite but less than ceramics. The composite restoration is initially formed on a replica of the tooth, which is initially light-cured for one minute on each surface. Subsequent layers are added and cured till full contour is built. Final curing is accompanied by inserting the die and/or restoration into curing oven that exposes the composite to additional light and heat for 8 to 10 minutes and allow it to cool, and then final trimming and finishing is done.

### CERAMIC INLAYS AND ONLAYS

Ceramics are popular due to the demand for esthetics and durability of restorations. Ceramic materials used

are feldspathic porcelain, castable ceramic (Dicor) and new machineable glass ceramic (Dicor MGC) used with CEREC systems. The physical and mechanical properties of ceramics are much closer to the enamel than to the composite, and have excellent wear resistance, and the coefficient of thermal expansion is very close to that of the tooth.

Cementing surfaces of dental ceramics are etched with acids to remove all the glossy matrix. Hydrofluoric acid is used to etch the feldspathic porcelain. Ammonium bifluoride is used to etch Dicor and Dicor MGC, as such etching increases the surface area. The increase in surface area enhances the micromechanical bonding of cement between ceramics and tooth surfaces.

### PORCELAIN INLAYS/ONLAYS FIRED ON REFRACTORY DIES

Mostly ceramic inlays and onlays are fabricated by firing dental porcelains on refractory dies. Porcelains are crystalline minerals of feldspar, alumina and silica dispersed in glass matrix. The porcelain restoration is made from ceramic powder mixed with distilled water or a special liquid, shaped into restoration form and then fired and fused to form transparent tooth-like restoration on the refractory dies.

Steps in the firing of porcelain inlays/onlays are the following:

1. Impression is made after final cavity preparation, and master working cast is poured of die stone.
2. Duplicate the die poured of a refractory investment to withstand porcelain firing temperatures.
3. Dental porcelain is added into desired cavity preparation of refractory dies and fired in oven. To compensate for sintering shrinkage, during firing, porcelain is placed in cavity in increments and on each time, firing must be done.
4. Ceramic restoration after taking out from die is cleaned of all investment, seated on master die and working cast for final adjustment and finishing.
5. Finishing and polishing is carried out. Ceramic inlays/onlays made by this technic have low startup cost. The ceramic powder and investment are inexpensive. Major disadvantage is the technique sensitivity. Fabricated inlays/onlays must be handled gently during try-in or cementation.

## FABRICATION OF PORCELAIN RESTORATIONS

- Teeth are prepared or reduced as per requirement.
- Impression is made, washed and excess water removed from the impression surface by pointed moist and squeezed cotton pellets, which absorb water by capillary action.
- 'Master' working cast is poured with type IV die stone.
- Die is duplicated very accurately in refractory investment material which can withstand porcelain firing temperature.
- Porcelain powder after mixing with distilled water (or liquid provided by manufacturer) is shaped in the desired form on the refractory die. Condensation of wet porcelain powder is done and excess water or liquid is removed gradually with clean tissue or blotting paper from whole of the mass by capillary action. In this way maximum possible porcelain powder is added so that porcelain powder particles are properly condensed together.
  - Dense packing of the powder particles is useful which produces:
    - lower firing shrinkage.
    - less porosity in fired porcelain.
  - Wet porcelain powder condensation is accomplished by the following methods:
    - Vibration: Mild vibrations help in packing the wet powder densely.
    - Spatulation: In this method, a small spatula is used to smoothen the wet powder and the wet particles condense together by which the excess water comes to the surface from where it can be removed.
    - Brush technic: In this method, dry porcelain powder is added to the surface with the help of a fine brush which absorbs the extra water.
- Pre-heating procedure:* Porcelain powder in restoration shape is placed in 'fire clay tray' and are fired in a furnace. In the beginning, in preheating, the porcelain is kept for 10 minutes in the outer low temperature chamber of the furnace and the door of the furnace is kept open so that water vapor and gases produced due to

organic combustion can escape. If water vapor and gases remain in furnace at a high temperature, the heating element may get damaged (Fig. 28.1).



Fig. 28.1: Porcelain furnace used to bake the ceramics

- At about 870°C (650°C for low fusing porcelain) combustion of organic matter is complete.
- The tray with furnace is pushed in the center of the furnace and firing cycle is initiated after closing the door of the furnace.
- The size of the powder particles of the porcelain influences the following:
  - Degree of condensation of porcelain
  - Density and soundness of the final restoration.
- Porcelain is a poor thermal conductor, hence too rapid heating may over fuse the outer layers but inner layers remain partially fused.
- Vacuum fired porcelain is denser and the surface is smoother.

## STAGES IN FIRING

Porcelain goes through different stages during firing known as bisque stages. In low bisque stage, material becomes rigid and porous. Particles lack very little shrinkage during this stage. In medium bisque stage, there is complete cohesion of powder particles which are still porous and lack translucency and high glaze. There is definite shrinkage in this stage. In high bisque

## 276 Textbook of Operative Dentistry

stage the porcelain mass exhibits smooth surface and the shrinkage is complete. Slight porosity may be seen in this stage.

During firing in the first phase, the water is lost, i.e. drying takes place. After drying stage, the temperature and time is controlled till final fusing, glazing and shading stages. As the temperature is raised, the porcelain particles fuse together by sintering. By densification, volume is reduced.

### Cooling

Slow cooling is preferred as too rapid cooling may result in surface crazing or cracking. Slow cooling is done by placing the restoration under a glass cover to protect it from cold wind and dirt contamination.

### Glazing and Shading

Glazes, shades and stains are added to provide natural appearance. By adding glass modifiers, the glaze fusing temperatures are reduced. Glaze layer is kept at least 50 micron thick. Stains are tinted glasses.

### Internal Staining

Produce life-like results.

### Grinding for Final Intraoral Adjustments

Grinding of occlusal surface of the polished porcelain for intraoral minor adjustments reduces the strength, increases discoloration and plaque accumulation. Wherever it is a must, porcelain is ground by very fine diamond round bur by arotor under water coolant.

The ground rough surface should be polished to make it smooth by very fine finishing disks, porcelain laminate, polishing laminate, polishing kit and or any very fine abrasive.

### Castable Glass (DICOR)

It was discovered in 1968 that certain glasses are modified with nucleating agent. These glass ceramics are stronger and have a higher melting point with variable coefficient of thermal expansion. In 1984, glass ceramic material was patented under the trade name DICOR. It was most widely used castable ceramic in dentistry. The steps in fabrication of castable glass are as follows:

1. After tooth and cavity preparation, and making of impression 'master' die and cast are fabricated with die stone.
2. A wax pattern is made and invested in special phosphate bonded investment, then burned out using a wax eliminating furnace.
3. The transparent casting glass is heated at 1100°C till casting glass is turned into white, opaque, semi-crystalline material.
4. Heating process increases the compressive, tensile strength and modulus of elasticity.
5. A special casting machine is used to melt the glass ingot. The melted glass ingot is slowly pneumatically pressed into the mold and casted. After cooling, the restoration is cleaned of all the investment.
6. Restoration is seated on master die and working cast for contour adjustment, final adjustment and finishing.
7. When all the fits, adjustment and finishing procedures are over, shading porcelains are applied and fired for better color matching and final finishing and glazing (Fig. 28.2).

**Advantages of DICOR:** Dicor has the following advantages: (a) An excellent marginal fit, (b) Relatively high strength, and (c) Higher surface hardness and wear resistance. It is very much similar to enamel. Dicor inlays are stronger than porcelain inlays made on refractory dies. Incidence of post-cementation fracture for cast dicor inlays is lower than for ceramic inlays made on refractory dies.

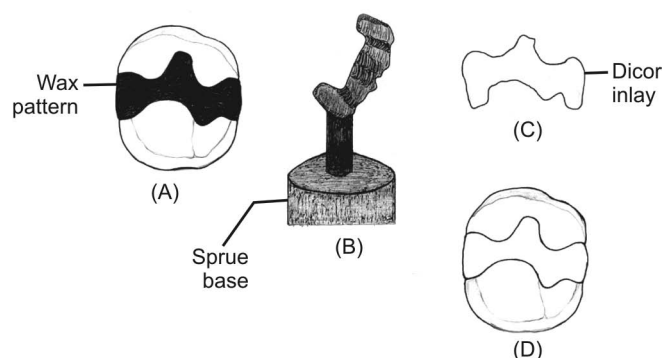
## RECENT PORCELAIN SYSTEMS

Recent porcelain systems include the following:

1. Magnesia core porcelains
2. Injection molded ceramics
3. Castable glass ceramics (Dicor)
4. Leucite reinforced (OPTEC HSP)
5. Glass infiltrated alumina core (INCERAM) and glass infiltrated spinel core ceramic (Inceram spinel)
6. Computer generated ceramic restorations.

### 1. Magnesia Core Porcelain

It has a high coefficient of thermal expansion ( $14.5 \times 10^{-6}/^{\circ}\text{C}$ ) and can be used with veneer porcelain which are bonded to metal. It is used as core as it has high strength among all the dental porcelains.



**Fig. 28.2:** Preparation of dicor inlay (A) Wax pattern for mesio-occlusodistal (MOD) dicor inlay on working cast. (B) Wax pattern on sprue base ready to invest. (C) Dicor inlay stronger, white and more opaque after completion of ceramming cycle. (D) Dicor inlay cemented

## 2. Injection Molded Core Materials (IPS Empress)

They are also used to form the core layer of porcelain crown. Leucite reinforced ceramic is blended with resins to form a plastic mass which is heated to 180°C and injected at 1,500 psi pressure into a mold prepared by utilizing the lost wax technique. Deflasking is then done followed by firing at a temperature of 1,300°C. The resins are burnt off by firing and a rigid core of aluminous ceramic is formed.

## 3. Castable Glass Ceramic (DICOR)

Commercially available castable glass for dental use are—Dentsply's Dicor—hydroxyapatite crystals in glass matrix. Dicor is a castable glass that is formed into an inlay, facial veneer or full crown restorations by a lost wax casting process. A glass ceramic is a material that is formed into the desired shape in glass then subjected to heat treatment. The strength of castable glass ceramic is comparable with aluminous porcelains.

## 4. Leucite Reinforced Porcelain (Optec HSP)

This type of porcelain has a higher leucite content than conventional porcelain. Its manipulation and firing is same. Leucite reinforced porcelain has good translucency and esthetics, higher strength than conventional porcelains. There is no need for special equipment. Disadvantages are potential marginal shrinkage during firing, fitting not as good as PFM crowns and not strong enough for posterior use.

## Indications

Inlays, onlays crown and veneer in anterior teeth.

## 5. Glass Infiltrated Alumina Core Ceramic (Inceram) and Glass Infiltrated Spinel Core Ceramic (Inceram Spinel)

An alumina core is made by a slip slash method. It is then infiltrated with glass at 1,100°C for 4 hours. This strengthens the core and reduces porosity. Inceram has good fit and marginal adaptation besides good esthetics. It has the best strength among all the ceramic restorations. Inceram bridge are weak when compared to PFM. It is comparatively less esthetic due to higher opacity of the core. Specialized equipment is needed.

## Indications

Anterior crown and anterior bridges (inceram spinel). The core material in this is spinel ( $\text{Mg Al}_2\text{O}_3$ ) infiltrated with glass.

## 6. COMPUTER GENERATED CERAMIC RESTORATIONS

Rapid improvements in technology have resulted into several computerized devices that can fabricate ceramic inlays and onlays, crown and bridge copings out of very high-quality ceramic blocks in a matter of minutes. Some CAD/CAM systems are very expensive laboratory based units requiring the submission of an impression or working cast of the prepared tooth in front of scanning device. Indirect computer generated ceramic restorations can be made chair side in CEREC<sup>®</sup> SYSTEM—CAD (Computer aided design) CAM (Computer aided manufacturing). The CEREC<sup>®</sup> system was the first commercially available CAD/CAM system developed for the rapid chair-side design and fabrication of ceramic restorations. The basic fabrication steps for restorations generated with the CEREC<sup>®</sup> system can be summarized as follows:

1. Optical impression taking: After tooth preparation, a scanning device is used to collect the information on the shape and size of the preparation. This step is termed an "optical impression". A video image of the prepared tooth is displayed to ensure proper positioning of the scanning device.
2. The system projects an image of the tooth preparation and surrounding structures on a



## 278 Textbook of Operative Dentistry

monitor, allowing the dentist or auxiliary personnel to use the CAD portion of the system to design the restoration. The operator must input and/or confirm the boundaries of the restoration, such as the position of the gingival margins and proximal contacts.

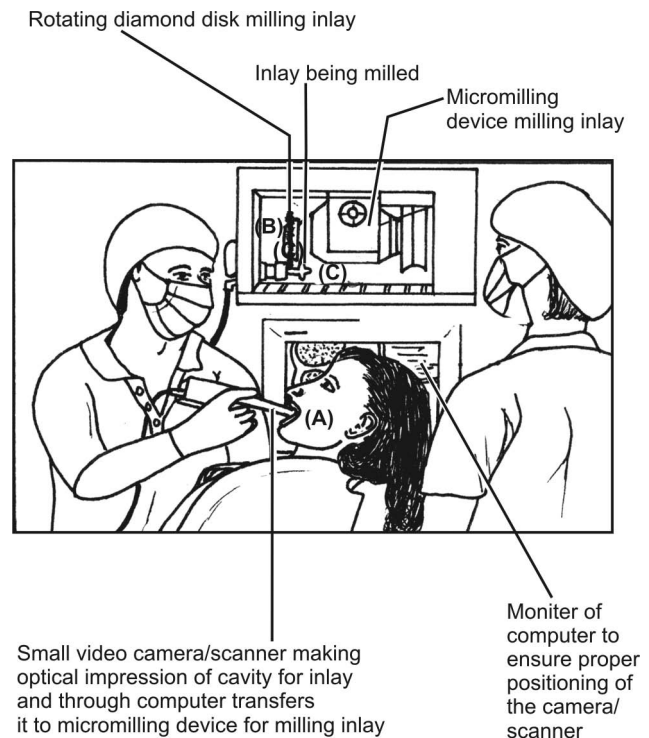
3. Once the restoration has been designed, the computer directs a micromilling device (CAM portion of the system), which mills the restoration out of a block of high quality ceramic in a matter of minutes.
4. The restoration is removed from the milling device, ready for try-in and cementation.

The CEREC system is designed to be used chair-side to make ceramic inlay or onlay on the same sitting which eliminates the need for a conventional impression, temporary restoration and multiple appointments, etc. Besides the speed of this system, a major advantage is the better quality of the ceramic restorative material. Blocks of “machinable ceramics” specifically for computer assisted milling devices are available. Since these blocks are fabricated under ideal conditions, they are among the strongest ceramics available for use in dentistry, and have many physical properties that closely match those of enamel. One such material is Dicor MGC. Dicor MGC is available in several shades and is tooth-colored throughout the thickness of the ceramic block hence external shading porcelains for color matching are not required. The only disadvantage of CAD/CAM systems is its high cost. However, technology is changing rapidly with lowering costs and improving properties (Fig. 28.3).

Disadvantage of DICOR, requiring application of shading layer, is that, due to grinding during occlusal adjustment, the shading layer may be removed. Hence little extra grinding is done to accommodate fresh shading layer and fresh shading layer is applied and fired. After finishing and polishing the preparation is cemented. Dicor MGC is available in several shades and is tooth colored throughout the thickness of ceramic block. This material eliminates the need to apply external shading porcelains for color matching with tooth.

### Advantages

1. Total time required for an inlay or onlay from tooth preparation to cementation is about one hour.
2. No laboratory expenses in inlays and onlays, but in crowns and bridges coping prepared by CAD/CAM system is to be veneered in the laboratory.



**Fig. 28.3:** CEREC CAD/CAM device 'Optical Impression' is made by placing a small video camera/ scanner over the prepared tooth. The signals are picked up. Class I preparation is there in the tooth (A) Scanner picking up signals, (B) Diamond disk milling inlay from ceramic block on signals from computer, (C) Inlay being milled for class I preparation in a few minutes

3. Conventional impression, multiple sittings and temporary restorations are not required.
4. Quality of the ceramic restorative material is very good as blocks of very good quality machinable ceramics for computer assisted milling devices are available in various natural tooth shades.
5. Permanent shade of the restoration - Prefused blocks of porcelain (Dicor MGC®) are available in various tooth colors and shades having same color and shade throughout the thickness of the block, hence the need for applying external shade is eliminated and there is no chance of fading or wearing out of the shade due to occlusal adjustments or wearing, etc.

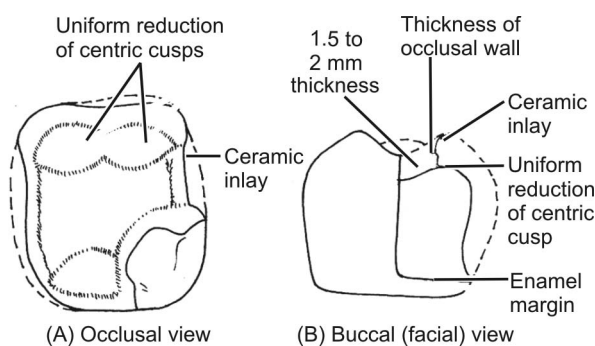
### Disadvantages

1. Very high cost of the equipment.
2. Special training is required.

3. More conservative tooth preparation is required.
4. Computer prepares rough occlusal anatomy without consideration of opposing occlusal anatomy and final occlusal adjustments are to be carried out.

### Cavity Preparation

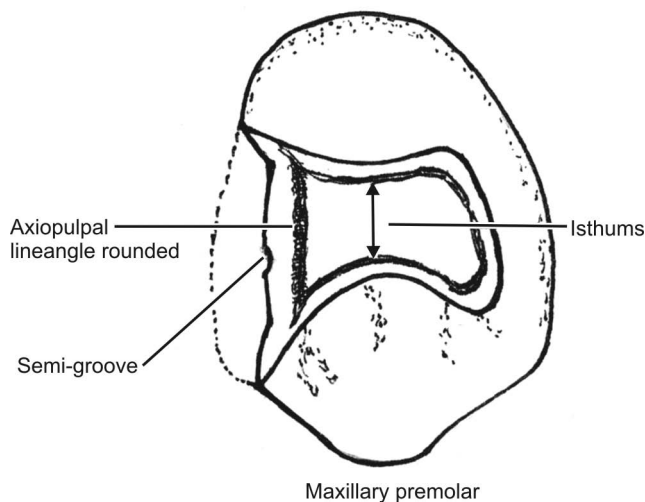
Indirect tooth colored inlays/onlays differ in the steps of cavity preparations, for each commercial system, and due to variations in the physical properties of restorative materials. The occlusal reductions for capping the cusp are approximately 1.5 to 2.0 mm. The amount of axial wall reduction varies depending on the restorative material, Dicor restoration need 1.2 to 1.5 mm. For all ceramic and composite systems, line and point angles should be well rounded to avoid stress in the tooth and restorations and reduce the chance of fractures (Fig. 28.4).



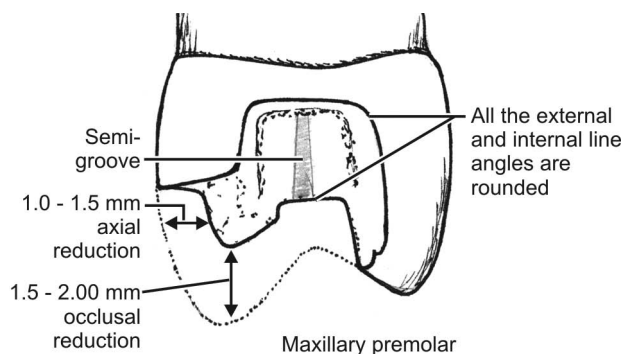
**Fig. 28.4:** Mesio-occlusodistofaciolingual (MODFL) cavity preparation for ceramic indirect inlay on maxillary first molar

In Initial cavity preparation the carbide burs used, should be tapering to make straight facial and lingual walls that diverge occlusally to allow the insertion and removal of restorations. During final cavity preparations, coarse diamond preparations points are used. The gingival to occlusal divergence can be increased from 2° to 5° per wall. Occlusal wall should be prepared to a thickness of 1.5 to 2.0 mm in depth. The pulpal floor should be smooth and flat. The facial, lingual and gingival margins of proximal box should be extended to clear the adjacent tooth at least 0.5 mm. During final finishing take care to remove all the stains on the axial walls (Figs 28.5 and 28.6).

A dental surgeon is required to make an impression of prepared tooth and adjacent teeth, which allow the fabrication of restoration on working cast in laboratories.



**Fig. 28.5:** A mesio-occlusal (MO) inlay preparation for tooth-colored inlay restoration. The width of isthmus is kept at least 2.0 mm to prevent the inlay fracture



**Fig. 28.6:** Mesio-occlusodistobuccal (MODB) inlay cavity preparation (Proximal view) capping the buccal cusp

Temporary restoration is necessary, for indirect system that requires atleast two appointments. Temporary cementation should be eugenol free, to ensure the proper setting for final composite resin cements.

Use very light pressure to evaluate the fit of inlays/onlays on the tooth,. When not completely seated, with help of a mouth mirror judge, where the proximal contour needs adjustment to allow final seating of restoration. After the restoration is completely seated, fine occlusal adjustments are done during try in, before final cementation is done. Slight excess of contour can be removed, using fine-grit diamond instruments.

### Cementation

Cavity site of inlay/onlay must be conditioned for cementation, to improve the bond of cement for processed composite restoration system that requires the use of solvent (ethyl acetate) the side of restoration which are placed in cavity walls prior to cementation.

For ceramic inlays/onlays, acids (Hydrofluoric) are used to etch the cavity site of ceramic restoration, etched ceramic treated with silanating agent further improves the bond to cements. After cementation remove the plastic matrix strips and wedges, examine all the margins. Fine diamond instruments are used initially to remove any excess of cement. During finishing the restoration, preserve the glazed surface of ceramic restorations. After occlusal adjustment, restoration must be polished in all areas. Polishing of ceramic restoration is completed with diamond-polishing paste with bristle brush.

### METAL CERAMIC (PORCELAIN FUSED TO METAL) RESTORATIONS

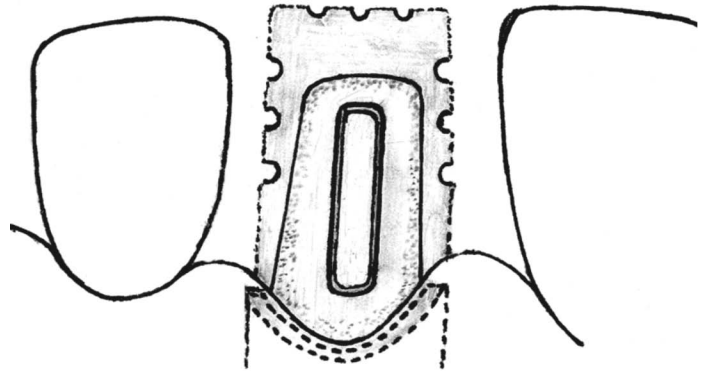
All ceramic restorations look very natural but are very brittle and subject to fracture. All metal restorations are very strong but esthetically very poor. Esthetics of porcelain and strength of metal have been combined in metal ceramic restorations. Because of these qualities this type of restorations is very popular (see Fig. 7.5).

#### Bonnet

For proper esthetic restoration the bonnet guide the correct placement of the die into the master cast. It helps in accuracy test and correct transfer. For preparing bonnet usually acrylic resin is used (Fig. 28.7).

Porcelains are used for these restorations hence these are popularly called as “Porcelain-fused to metal” restorations. Mostly alloys of metals are used for this purpose. Alloys and porcelain used should have following properties:

1. Ceramics and alloys should form a strong bond - most common cause for the failure is debonding of porcelain from the metal.
2. Porcelain should fuse at a much lower temperature than the melting temperature of the metal. Alloy should not deform or sag at porcelain fusing temperature.
3. Porcelain and alloys should have matching coefficient of thermal expansion so that porcelain should not crack or separate from alloy on cooling.



**Fig. 28.7:** Bonnet is used for testing the accuracy of die and for transfer of dies to master cast

4. Alloy should have a high modulus of elasticity so that it can share greater proportion of stress than the adjacent porcelain.

### CAST COPING

On the facial side the thickness of the metal is about 0.3 to 0.4 mm thick. It is covered with opaque porcelain which is about 0.3 to 0.4 mm thick. The body porcelain is about 1 mm thick on the labial side and the transparent porcelain is about 0.3 to 0.5 mm thick at incisal third. At the middle third of the crown it is about 0.2 to 0.3 mm thick and at the cervical third it is about 0.1 mm thick.

### PORCELAIN-METAL BOND

The bond between metal and ceramic must be strong and durable. There are generally two types of bondings:

1. Micromechanical bonding
2. Chemical bonding.

#### Micromechanical Bonding

The fused ceramic behaves like a viscous liquid and flows over the metal covering and adapting to the minute irregularities over the surface and forming micromechanical bonds. The irregularities must be regular without any sharp line angles and be microscopic, to avoid stress concentration leading to fracture of porcelain. This ability of the fused porcelain to intimately adapt to the metal surface is called “wetting” which mainly depends on surface tension, etc. For good micromechanical bonding the regular irregularities on the coping surface

produced by sand blasting produce strong bonding than grinding with rough diamond or stone. There is no major mechanical interlocking as the outer surface of the metal coping is apparently smooth.

### Chemical Bonding

The gold alloy coping contains about 1 percent of base metals such as iron, indium and tin which form a surface oxide. This surface oxide is responsible for bonding metal with ceramic. This bond is chemical in nature. Fused porcelain diffuses into the metallic oxide layer and metallic oxide layer diffuses into the porcelain. All metallic oxides do not provide good chemical bonding. Iron, indium and tin are good oxides for providing satisfactory chemical bonding. Chromium metal oxides do not produce good chemical bonding with porcelain.

The compatibility of the metal ceramic is important as:

1. The metal should not interact with ceramic so as to visibly discolor it and affect the esthetics.
2. Metal-porcelain bond must be durable and stable at interface to withstand masticatory stresses.

### COMPOSITION OF METAL CERAMIC ALLOYS AND CERAMICS

Most of the nickel-chromium alloys for metal ceramic work contain 62 to 76 percent nickel and 13 to 28 percent chromium besides cobalt, beryllium, molybdenum, Tungsten and Ruthium. The cobalt chromium alloy contain by weight 52 to 68 percent cobalt, 24 to 33 percent chromium and 2 to 7 percent molybdenum (Table 28.1).

**Table 28.1:** Typical base metal alloys for metal-ceramic restorations

| S. No. | Alloy Name (Supplier)            | Composition (Weight Percent) |     |    |     |    |    |    |
|--------|----------------------------------|------------------------------|-----|----|-----|----|----|----|
|        |                                  | Ni                           | Co  | Cr | Be  | Mo | W  | Ru |
| 1.     | Rexillium III (Jeneric/Pentron)  | 76                           | 0.3 | 14 | 1.8 | 5  | -  | -  |
| 2.     | Litecast B (Williams Dental Co.) | 78                           | -   | 13 | 1.7 | 4  | -  | -  |
| 3.     | Neptune (Jeneric/Pentron)        | 62                           | -   | 22 | -   | 9  | -  | -  |
| 4.     | Forte (Unitek/3M)                | 62                           | -   | 22 | -   | 9  | -  | -  |
| 5.     | Genesis II (J. F. Jelenko & Co.) | -                            | 53  | 27 | -   | -  | -  | 3  |
| 6.     | Ultra 100 (Unitek/3M)            | -                            | 52  | 28 | -   | -  | -  | -  |
| 7.     | Novarex (Jeneric/Pentron)        | -                            | 55  | 25 | -   | -  | 10 | 5  |

The melting temperatures of the base metal alloys are high. Higher the melting temperature of the alloy higher will be the shrinkage and more is the compensation required. Chemically pure titanium and alloys containing titanium, aluminium and vanadium are also used for metal-ceramic restorations. Composition of ceramics for metal ceramic restorations are almost same as all ceramic restorations except for an increased alkali content, which increases co-efficient of thermal expansion to match with that of metal used for coping (Fig. 28.8).



**Fig. 28.8:** Metal ceramic restoration on maxillary central incisors and right lateral incisor

Metal Ceramic Bond strength is higher in vacuum firing and multiple firing, as compared to single firing.

Three vacuum firings produce bond strength of 615 to 680 kg/cm<sup>2</sup> (55.20 to 66.50 MPa).

### FAILURES OF METAL CERAMIC RESTORATIONS

Majority of metal ceramic bond fracture at the metal oxide interface and not at the porcelain oxide interface. All steps of metal-ceramic technique are highly precise and critical, and should be followed carefully, especially the metal frame work designing for long lasting results.

Failure due to unfitting casting may be due to the following reasons:

1. Fusion of porcelain grains inside the coping.
2. Casting contamination by low fusing alloy components from the metallic die.



3. Thin margins of metal buckle due to contraction of porcelain hence it should not extend over thin metal margins.
4. Elastic deformation of non-rigid metal structure.
5. Forceful fitting may result in elastic deformation of the metal and breakdown in porcelain bond.

## HANDLING HAZARDS AND THEIR PREVENTION AND PRECAUTIONS

High concentration of dust and vapor of beryllium and dust of nickel may be harmful. During melting, finishing and polishing of alloys containing beryllium, filtration and exhaust should be used to minimize side effects.

Prolonged exposure of beryllium vapor and dust may cause acute and chronic beryllium disease giving rise to contact dermatitis to severe chemical pneumonitis which may be fatal. The symptoms are general weakness, coughing, chest pain and pulmonary dysfunction. It is advisable that in dental laboratories where casting, finishing and polishing of the metal takes place routinely exhaust system must be provided.

### Base Metal Alloys

ADA specification (1984) defines base metal alloy as an alloy that contains less than 25 percent weight of the noble metals like gold, platinum and palladium, Base metal alloys include Co-Cr-Ni, Cr-Ni, Cr-Be, and Ti-Al-V. Pure Titanium is also used for dental castings and is a base metal element.

No alloy is ideal in all respects for metal ceramic restorations.

### Advantages

Advantages of base metal alloys are as follows:

1. They are harder and stiff and do not sag at high temperature.
2. Nickel based alloys have much superior creep resistance at porcelain fusion temperature than gold based and platinum based alloys.
3. Cheaper than gold based alloys.
4. They are rigid and stiff and can be used for longer span bridges than gold alloys under the same load.
5. Flexibility is half than that of gold alloys.

### Disadvantages

Disadvantages of base metal alloys are as follows:

1. More technique sensitive.
2. Casting is difficult than gold-palladium or silver-palladium alloys.
3. Oxide layer from metal coping is poorly adherent to porcelain, hence porcelain chips off very easily.
4. Small variations in composition very much change its properties and also metal-ceramic bond strength.
5. With nickel-based alloys the chances of allergic reactions are more.
6. For the convenience in casting all nickel based alloys need 1.8 weight percentage of beryllium.
7. All Beryllium containing alloys are more difficult to solder properly. There are voids in the solder.
8. Because of excessive hardness the occlusal adjustments, grinding and polishing and removal of the defective restoration, etc. are much chair side time consuming.

## CLINICAL PERFORMANCE

Base metal alloys are gradually replacing high noble metal alloys for metal ceramic work. The successful restoration depends on its designing, skill and accuracy of the operator and properties of the materials used. Base metal alloys are cheaper and lighter in weight. If for a casting 8 gm gold alloy is required, in base metals same casting can be done in 4 gm of alloy. The weight of same volume of base metal alloy is half than that of gold alloy. Twice gold alloy by weight is required to make the same casting as in base metal alloy.

Seghi et al, (1995) assessed the relative fracture toughness and hardness of new dental ceramics and concluded that alumina reinforced materials had highest fracture toughness values. Lopresti et al (1996) compared the microleakage of CAD-CAM porcelain inlay restorations cemented with dual cure resin cement and direct composite filling and concluded that CAD-CAM generated porcelain inlay cemented with dual cure resin cement have better marginal seal than direct composite filling. Mathai and Sripathi (1984) observed that tricalcium phosphate bioceramic can be used in edentulous patients with extreme resorption of mandible with mental foramen opening near or directly at the crest of the residual bony process.

*Vera bond* It is a non-precious ceramic alloy.

*Permaglaze™* It is a low fusing porcelain glaze material that is resistant to acids.

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The carious teeth or other defects in teeth can be restored by various restorative materials such as amalgam, composite resins, direct filling gold and cast metal restorative materials. These restorative materials have their own indications, contraindications, and limitations. In case of amalgam, composite resin or direct filling gold restorations, sufficient tooth structure support is necessary for their satisfactory service. When this sufficient tooth structure support is not available, such as in case of marginal ridge and cusp breakdown, then cast metal restorations are better option. The majority of cast metal restorations are made from alloys formed by combining gold with other metals such as silver, copper, zinc, platinum and palladium.

In operative dentistry, cast metal restorations are used mainly in three forms; (1) Inlay (2) Onlay and (3) Partial Crown. The procedures are completed atleast in two appointments. In first appointment, tooth is prepared and the impression is taken. Then the cast is made on the impression and on this cast, wax pattern is made. This is called making the wax pattern by indirect method. The wax pattern can also be made directly on the prepared tooth in the oral cavity. In this method impression is not taken and cast is not prepared. It is known as direct method for making wax pattern. In laboratory, mold is prepared by investing the wax pattern. The mold is heated to eliminate the wax pattern. Then cast metal restoration is made by casting, i.e. forcing the molten alloy in the empty mold. The molten metal takes the shape of wax pattern and solidifies. After this the cast metal restoration is taken out of the mold and is finished and polished. In second appointment, this cast metal restoration is cemented on the tooth in the mouth of the patient. All procedures described are for gold alloy cast restorations.

*Inlay:* An inlay is a classic intracoronal restoration which is prepared extra orally and cemented in the cavity of the tooth. Inlay may cap none, or may cap all but one cusp of a tooth.

*Onlay:* An onlay caps all the cusp but not complete crown.

*Partial crown:* In partial crown a part of the crown remains uncovered and rest of the crown is covered like three-quarter crown and seven-eighth crown.

*Crown:* A crown completely covers the crown of the tooth.

## CLASS II INLAY AND ONLAY

*Class II inlay:* Class II inlay essentially involves proximal surface or surfaces of a posterior tooth, usually may involve occlusal surface and also may involve facial and/or lingual surface(s) and caps none or may cap all but one cusp of a tooth (Fig. 29.1).

*Class II onlay:* Class II onlay is a modification of the inlay and involves the proximal surface or surfaces, and may involve facial and/or lingual surface/s of a posterior tooth and caps all the cusps.

Inlay and onlay are more commonly prepared hence they have been described in detail

## Indications of Metal Inlay and Onlay

The indications of metal inlays and onlays are as follows:

1. In extensive proximal surface caries in posterior teeth.
2. Root canal treated molars and premolars are restored by onlay to strengthen the remaining tooth structure.
3. Tooth requiring extensive restoration with green stick fracture line in enamel and dentin. The cast metal inlay/onlay can brace the tooth with green stick fracture line against further injury to prevent fragmentation of the tooth.
4. To maintain and restore proper interproximal contact and contour and for occlusal plane correction.
5. When extension of the mesiodistal dimension is required to build up the contact area with adjacent teeth.



**Fig. 29.1:** Maxillary arch showing the following:

A. (a) Mesio-occlusal cavity preparation for inlay on right second premolar (b) Preparation for onlay on left first molar covering all cusps (c) Left central incisor showing preparation for jacket crown (d) Preparation for dowel crown on left lateral incisor

B. Restorations for all the preparations shown in Fig. 29.1 (A) finished and polished, on the respective teeth.

6. Abutment teeth of removable partial denture should be restored by cast metal inlay or onlay because they provide better physical properties to withstand the

forces imparted by the partial denture, the contours of the rest seats, guiding planes, and other aspects of contour related to the partial denture are better controlled when the indirect technique is used.

7. In posterior teeth with heavy occlusal forces and attrition.

### Contraindications of Metal Inlay and Onlay

The contraindications of metal inlay and onlay are as follows:

1. Where esthetics is prime consideration because metal inlay and onlay display metal color.
2. When patient cannot come for second visit.
3. Where expected life of a tooth is short, i.e. periodontally involved teeth in aged persons, or in deciduous teeth nearing their shedding time, because of higher costs and shorter service duration.
4. In those cases in which caries extends in facial, lingual and multiple surfaces. In these cases, full crown is indicated.
5. For patient of low economic status, inlay and onlay are contraindicated because of higher costs.
6. In those cases which are already treated by different metals, because dissimilar metals cause electrical and corrosive activity in mouth when they come in contact with each other or through saliva.

### TOOTH (CAVITY) PREPARATION FOR CLASS II CAST METAL (GOLD ALLOY) INLAY

Basic concepts of cavity design for cast restorations are as follows. For cast restoration, cavity is prepared in carious or defective tooth. In direct method wax pattern is prepared inside the oral cavity. In indirect method cast or die is prepared after taking impression. In this cast or die, wax pattern is prepared. This wax pattern should be removed from cast or die without any distortion. For this purpose, some fundamental differences should be followed during preparation of class II inlay or onlay cavity. In comparison to direct filled class II cavity design, there are some basic concepts of cavity design for cast restorations.

### Inlay Taper

For unobstructed removal of the wax pattern and seating of the subsequent casting, intracoronal and extracoronal



tooth preparation should be in taper. A basic requirement of all cavity preparations for the intracoronal cast restoration is that the cavity walls must diverge from gingival to occlusal and it may range from 2 to 5 degrees per wall in the line or path of withdrawal. A basic requirement for extracoronal tooth preparation is also similar and in this all prepared walls must converge from the cervical to the occlusal surface. This is the concept of taper.

Throughout the cavity preparation involving occlusal surface for a cast inlay and onlay and reduction of tooth for crown, the cutting instrument should be parallel to the long axis of the tooth and thus the preparation develops a line of withdrawal. This line of wax pattern withdrawal also describes the path of insertion and removal of the casting and is the axis of taper. If longitudinal walls of extracoronal and intracoronal preparations are unusually short, a maximum of 2 degrees occlusal divergence for intracoronal and 2 degrees occlusal convergence for extracoronal preparation is desirable to increase the retentive potential. If cervical to occlusal wall height is more, then degree of occlusal divergence and degree of occlusal convergence should be increased for intracoronal and extracoronal preparation respectively, although it should never exceed 10 degrees.

For shallow Class I or class II preparations the axis of taper is generally parallel to the long axis of the tooth and for a class V the axis of taper generally is perpendicular to the long axis of the tooth. The angle formed by the convergence of the tapered cavity walls to a point of their intersection is bisected by line of withdrawal. The amount of taper upon opposing cavity walls is described by this convergent angle. The total relationship of all prepared walls of the cavity can be best described by cone angle taper.

## Bevels

An accurate wax pattern and its subsequent casting may not assure its accurate adaptation to the margins of tooth preparation. Adaptation is most easily accomplished with a wedge-shaped cast gold margin because closure occurs when the wedge-shaped margin is burnished. Objective of bevel is to form a metal wedge of 30 to 35 degrees thus enhancing the opportunity to attain closure at the interface of cast gold and enamel

and cementum. By the beveling, a strong enamel margin with an angle of 140 to 150 degrees can be produced. In this way, 30 to 40 degrees wedge-shaped margin of cast metal is produced.

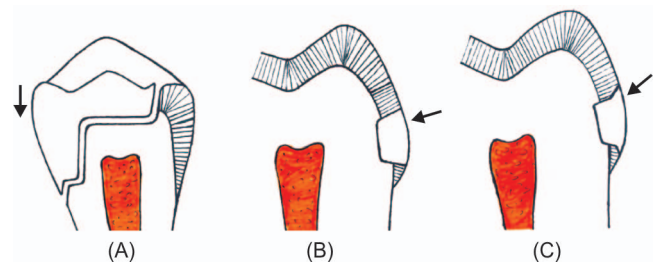
Mostly, bevel is not required during inlay cavity preparation because the morphologic anatomy of the tooth in combination with the prepared cavity wall will result in an appropriate wedge shaped metal margin. This is due to the presence of cusp inclines at the occlusal surface of tooth. In these conditions, if a bevel is given during cavity preparation, it results in a very thin wedge shaped metal margin. It is easily deformed by occlusal forces. The desirable metal angle at the margins of inlays is 30 degrees at the gingival margin and at other margins it should be 40 degrees. Bevels help to maintain the marginal seal of a cast restoration (Fig. 29.2).

## Variations in Proximal Margin Design

The design of the proximal margins will vary with the following conditions:

1. The extent of tooth tissue lost/carious/damaged
2. The location of that loss/carious/damage
3. The positional relationship with the adjacent teeth
4. The tooth form
5. The need for retention form
6. Convenience.

The box slice, auxiliary slice and modified flare are basic designs and are used to finish and extend walls and margins of the proximal box that has resulted from the removal of old restorations or dental caries. Each design may have specific advantages and disadvantages.



**Fig. 29.2:** Bevels (A) Sliding lap joint with approximately 30° metal margin, (B) Butt joint with 90° metal margin, (C) Lap joint with approximately 35° metal margin. Direction of arrow shows line of placement of inlay

### Box Preparation

Box preparation is a very important step of cast restoration in many aspects. In a proximo-occlusal preparation, first of all the occlusal retentive preparation is made as dovetail. Then the cavity is made at the proximal side where box preparation is to be done. It extends more in the proximal side till the bur end penetrates the enamel. The proximal enamel including the damaged part is removed. Gingival wall and other walls are finished. Facioproximal groove and linguoproximal grooves are made on the facioproximal wall and linguoproximal wall respectively (Fig. 29.3).

### Slice Preparation

Slice preparation is the conservative cutting of the proximal surfaces to form the extended buccal and lingual finish lines for lap joint. The slice preparation produces sound enamel margins with no unsupported enamel (Fig. 29.4).

### Auxiliary Slice

Auxiliary slice provides external support to weakened tooth surface when it is subjected to high stress during function. It is partially made around the proximal line angle, which provides additional tooth support (Fig. 29.4).

Advantages of auxiliary slice are as follows:

1. Minimal tissue is lost, hence resistance form is greatly enhanced, reducing the possibility of tooth fracture.
2. Auxiliary slice around the lingual proximal line angle of a tooth will aid in preventing the buccal displacement of a casting.

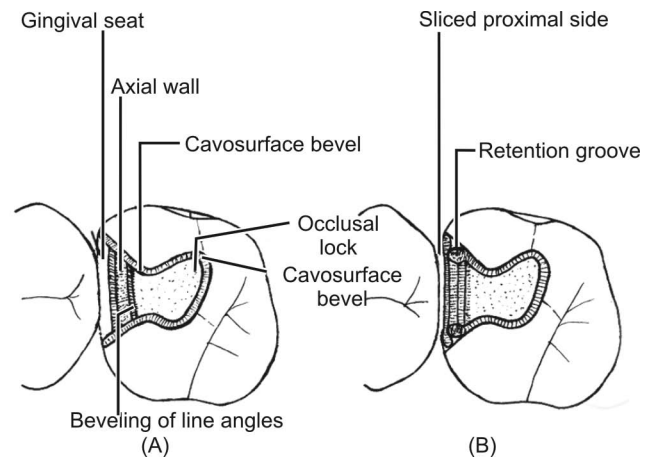
### Modified Flare Preparation

Modified flare has the advantages of both box preparation and slice preparation. Disking of buccal and lingual walls is done. Cavo-surface angle is increased (Fig. 29.5).

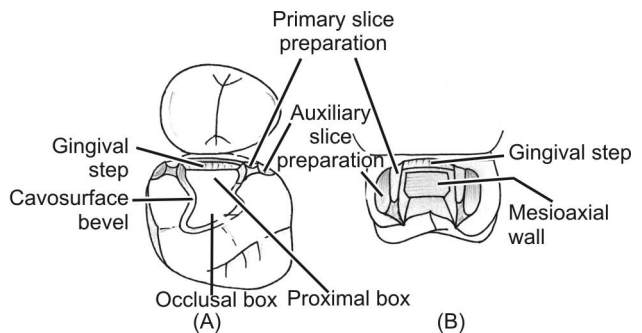
### Final Tooth (Cavity) Preparation

Final cavity preparation takes place according to the case to case modification.

The deep carious lesion should be carefully removed, preventing pulp exposure. The deeper part of the cavity after excavation should be protected by the calcium



**Fig. 29.3:** Cavity preparation for cast metal restoration in maxillary molar (occlusal view) (A) Mesio-occlusal direct wax pattern—box preparation, (B) Mesio-occlusal inlay cavity for an indirect impression—Slice preparation with retention grooves

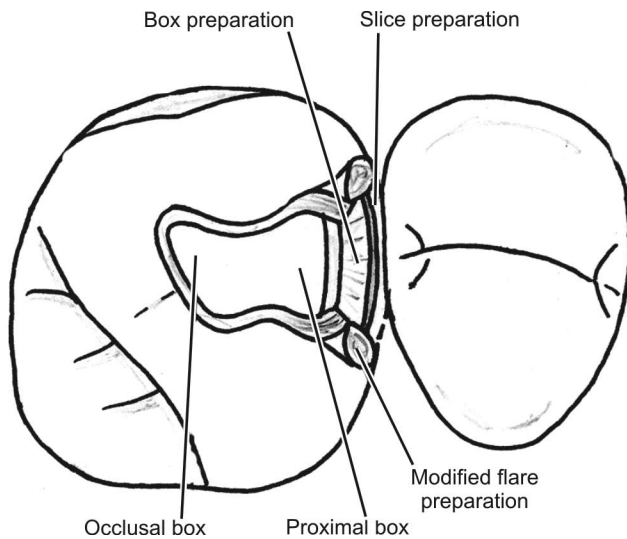


**Fig. 29.4:** Mesio-occlusal inlay preparation for indirect wax pattern utilizing primary slices and auxiliary slices. Juncures of primary slices with buccal and lingual auxiliary slices are extracoronal and form a convergent taper towards the occlusal surface (A) Occlusal view, (B) Proximal view

hydroxide layer and then glass ionomer cement base is placed. These procedures are done under proper isolation with either cotton rolls or rubber dam. Occlusal and gingival margins are finally beveled.

### Advantages of Gingival Bevels

1. Weak enamel is removed.
2. Because of this preparation the gingival margin has a lap sliding fit which provides better fit at this region.
3. A beveled surface can be easily burnished.



**Fig 29.5:** Modified flare preparation: Occlusal view of mesio-occlusal preparation for indirect method showing box and slice preparation

#### **Advantages of Secondary Flare (Auxiliary Slice Preparation)**

1. The proximal walls having secondary flare encourage self-cleaning as margins are extended into the embrasures.
2. Easy finishing of the restoration
3. Beveling of angles help in better burnishing of the metal.
4. More blunted and stronger margins are produced.

Secondary flare is not given in the areas where esthetics is more important. For example, mesiofacial proximal wall of premolars and first molars. Occlusal bevel is made by flame shaped diamond bur. The occlusal margin metal of the inlay is made at 40 degree metal angle. It increases the strength of the margin. In the gingival margin metal angle should be 30 degrees.

#### **MESIOOCCLUSODISTAL (MOD) TOOTH (CAVITY) PREPARATION FOR CAST METAL RESTORATION**

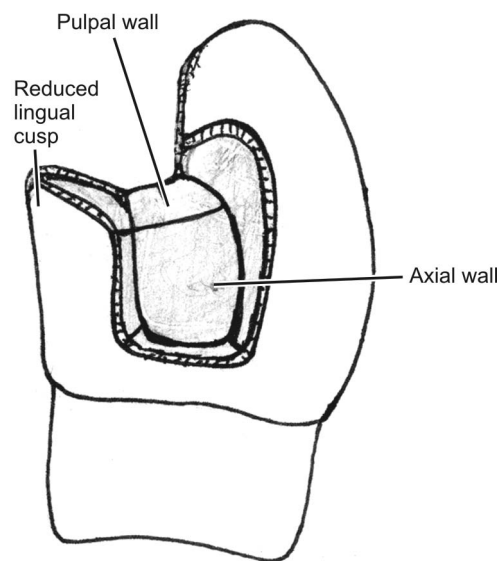
When both the proximal surfaces are carious or one proximal surface is carious and other is prone to caries and is likely to undergo decay shortly then both proximal sides are involved in cavity preparation which shares common occlusal isthmus. The proximal preparation

of both proximal sides of tooth is approximately same to provide better retention.

#### **CLASS II TOOTH (CAVITY) PREPARATION FOR CAST METAL (GOLD ALLOY) RESTORATION OF THE MANDIBULAR FIRST PREMOLAR**

The anatomy of the mandibular first premolar is unique in many respects which require special attention during cavity preparation for the health of the pulp, the retention and strength of the cast restoration. Capping of the lingual cusp may be required.

Occlusal depth should not be more than 2 mm. The occlusal floor of the cavity should be according to pulp horn, i.e. more pulpal toward lingual side (Fig. 29.6).



**Fig. 29.6:** Reduction of lingual cusp of mandibular premolar for capping without need for pins

Occlusal transverse ridge is involved when it is decayed or when both proximal surfaces are involved (in case of mesio-occlusodistal cavity preparation) or when tooth is too small. In single proximal side preparation (class II cavity), occlusal dovetail preparation is created for proper retention. If transverse ridge is strong, smooth and without a faulty central groove, then it should be conserved while preparing a distoocclusal cavity as this conserves tooth structure and the restored tooth is stronger.

## ESTHETIC MODIFICATION IN CLASS II TOOTH (CAVITY) PREPARATION

In maxillary premolars and first molars, the class II cavity involving mesioproximal side is visible during various mandibular movements. Hence, mesioocclusal cavity in these teeth where esthetics is important, requires less mesiofacial flare for the minimal metal exposure or no metal exposure. Secondary flare is not given in these teeth and the walls and margins are developed preferably with a chisel or hatchet.

### Buccal and Lingual Groove Extension

When a tooth to be restored with metal casting, has carious buccal or lingual groove, then the tooth preparation should include this groove also. This is called buccal or lingual groove extension (Fig. 29.7). After cavity preparation is done, a straight carbide or diamond bur is extended from the cavity to the facial or lingual groove according to the case. A 30 degree marginal metal bevel is also given at these extension sides. This groove increases the retention of the casting.

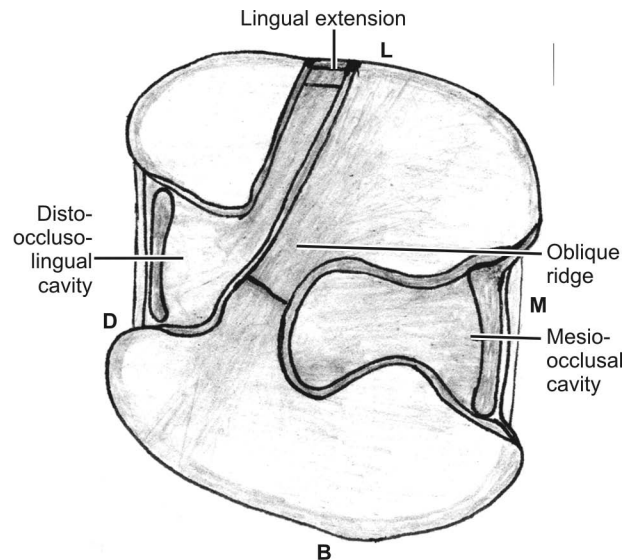
## CLASS II TOOTH (CAVITY) PREPARATION FOR ABUTMENT TEETH

If teeth adjacent to the connector of the removable partial denture (RPD) are restored by cast metal restoration in class II lesion, then the proximal surface bevel is extended more gingivally. This modification is brought about for easy cleansing of the gingival area of the teeth since these teeth have difficulty in proper cleaning. It is important not to extend the gingival floor too much apically as it may cause pulp exposure.

### Maxillary Molars with Unaffected and Strong Oblique Ridge

The maxillary molars having proximal lesions on both sides are restored with cast metal restoration. If the oblique ridge is sound then tooth preparation is done by preserving it as cutting of the oblique ridge in the maxillary molar causes considerable loss in tooth strength. If oblique ridge is preserved then two separate cavity preparations are done, one in the mesial side and the other in the distal side (Figs 29.7 and 29.8).

Mesial side cavity i.e. mesioocclusal cavity is same as described earlier in class II cavity preparation for the

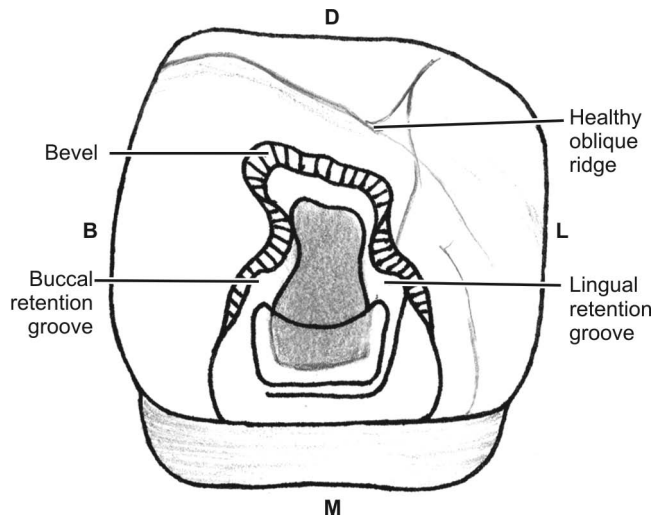


**Fig. 29.7:** Cavity preparation for cast metal inlays to both proximal surfaces of maxillary molar having strong and unaffected oblique ridge with lingual extension (D = Distal, B = Buccal, M = Mesial, L = Lingual)

cast metal restoration (Fig. 29.8). During cavity preparation on the distal side, when the lingual developmental groove is carious or prone to caries, it is also involved and distoocclusolingual cavity preparation takes place. This distoocclusolingual cavity preparation is also popular because it prevents fracture of the distolingual cusp. The important point in this preparation is creating adequate retention and resistance form. It is obtained by the following means.

1. Wall of the cavity should be approximately parallel or creating maximum of 2 degree occlusal divergence.
2. Creation of the lingual groove, if indicated.
3. Involvement of distolingual cusp in the casting, if indicated.
4. Lingual surface groove extension should not be very close to the distal proximal side, otherwise the distolingual cusp and the underlying tooth tissue may become weak. Lingual extension groove is made when the proximal box and the lingual proximal walls have been made.
5. Certain line angles are made prominent.
6. Mesioaxial and distoaxial grooves are made in the lingual surface groove extension and lingual and facial retention grooves in the mesial or distal boxing (Fig. 29.8).





**Fig. 29.8:** Mesio-occlusal cavity preparation on maxillary molar for cast metal inlay having unaffected oblique ridge (mesial aspect) (D = Distal, L = Lingual, M = Mesial, B = Buccal)

### Fissures in the Facial and Lingual Cusp Ridges

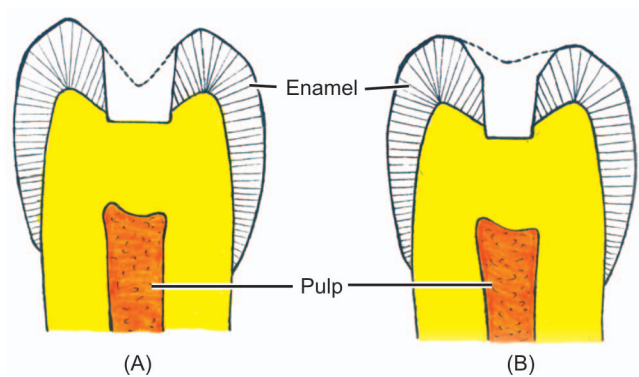
Carious, deep or defective lingual and facial cusp ridges are sometimes included in the cavity preparation. Sometimes these are extended almost to or through the facial and lingual cusp ridge. In order to include these ridges, the preparation should not remove the dentinal support of the respective cusp, but it is achieved by the occlusal bevel. Occasionally, inclusion of these ridges is avoided by proper enameloplasty to remove the carious part (Figs 8.56, 29.9 and 29.10).

If these fissures are to be included in the cavity preparation, then the margin should not be extended to the height of ridge. If bevel preparation reaches to the height of the ridge, then it should be extended to the facial or lingual surface.

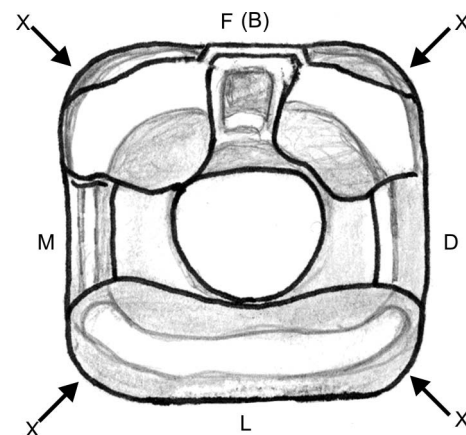
Fissures in the marginal ridge: Mesial and distal marginal ridges are also sometimes included in the same fashion as described for the fissure in the facial and lingual cusp ridge. When this preparation reaches the contact area then proximal preparation is extended to include the contact area.

### CAPPING OF CUSP

When the occlusal caries is extensive then more cutting is required including most of the cusp to remove all the carious lesion or undermined enamel. When removal



**Fig. 29.9:** (A) Tapered occlusal walls finishing on steep cuspal inclines that do not require special beveling to produce easily adopted casting margins, (B) Tapered occlusal walls finishing on flattened areas of enamel require beveling for easy adaptation of casting margins

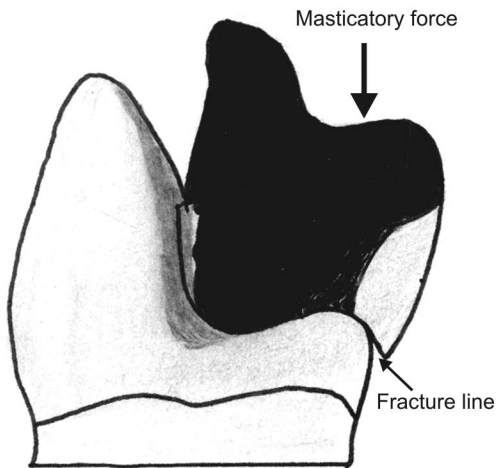


**Fig. 29.10:** MODF onlay retention form is improved by facial and lingual skirt extension. Skirt is blended into primary flare. Retention and resistance forms are enhanced by skirting all four transitional line angles (X) of tooth (F= facial, L= lingual, M= Mesial, D= Distal)

of carious structures causes cutting of the occlusal surface more than half the distance from primary occlusal groove to the cusp tip, the capping of the cusps is desirable and capping is essential if two-thirds or more of this distance, is involved (Figs 8.9, 29.6 and 29.11).

Capping of cusp serves the following purposes:

1. It prevents fracture of the underlying tooth structure.
2. Occlusal margins of the cavity are placed away from strong occlusal forces.



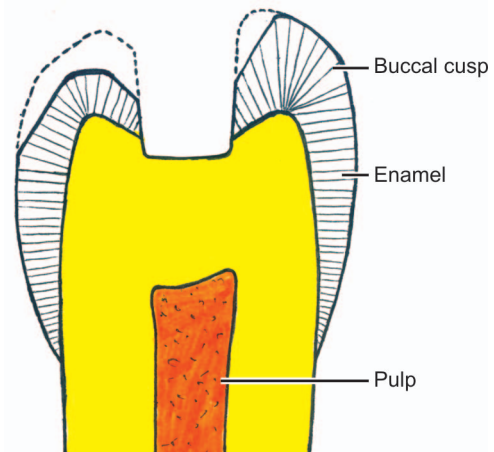
**Fig. 29.11:** Class II metal cast restoration: Fracture of lingual cusp and wall occurs if weak lingual cusp is not properly protected

Cusp reduction should be done by making a groove. It helps in accurate and uniform cutting. Cusp reduction is done according to the situation of a particular cusp. All the cusps do not require equal reduction. A cusp in infra occlusion is reduced less to meet the same level. Lingual or buccal developmental groove should be reduced along with the adjacent reducing cusp. This cusp reduction is completed by making longitudinal wall that has equal depth as prescribed cusp reduction.

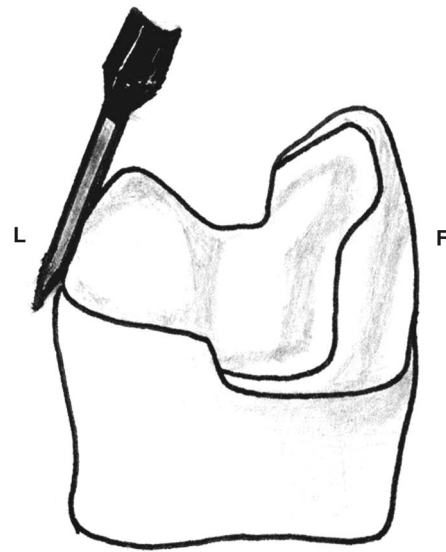
Retention grooves are made at the proximal walls of the box to increase retention and resistance form as cusp reduction leads to decreased retention form. These grooves also add resistance form to the preparation. A reverse bevel or counter bevel is formed on the facial or lingual side of the reduced facial or lingual cusp respectively. Reverse bevel is contraindicated in the areas where esthetics is a prime requisite like facial margins on maxillary premolars and the first molar (Figs 29.12 to 29.14).

### INVOLVEMENT OF SMOOTH SURFACE CARIES OR DEFECTIVE AREA ON THE FACIAL AND LINGUAL SURFACE IN THE PREPARATION

Caries degradation is more common in the pits, fissures and grooves but sometimes it extends to the smooth



**Fig. 29.12:** Esthetic cuspal protection (buccal cusp) with simple hooding of buccal surface area. Outer and inner incline reduction of lingual cusp for capping

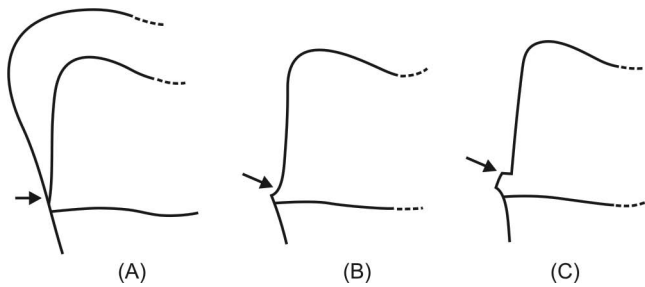


**Fig. 29.13:** To reinforce the lingual cusp to prevent its fracture skirt extensions are prepared with fine grit diamond bur for class II cast metal restoration (F= Facial surface, L= Lingual surface)

facial and lingual surfaces also, especially in extensively decayed cases. In these cases the cavity preparation for cast metal restoration requires some modification.

### Caries on the Distofacial Cusp of Maxillary Molars

If the caries is superficial, then the lesion is removed by Enameloplasty using flame shaped diamond bur.



**Fig. 29.14:** Preparation of commonly used extracoronary cervical finish areas. (A) Bevel, (B) Chamfer, (C) Shoulder with Bevel

Involved facial surface and the distofacial corner is reduced. Margin of the facial surface preparation should be proper gingivoocclusally.

Deep caries present on the distofacial surface is removed. The resistance form of the tooth is increased by creating shoulder extending from distal gingival floor and around, to include the affected facial surface. Faciogingival and facial margins are beveled to form a casting having 30 degree and 40 degree metal at the gingival margin and facial margin respectively. Sometimes lingual groove extension is provided to enhance retention and resistance form.

### CLASS III TOOTH (CAVITY) PREPARATION

Class III metal castings are generally restricted to the small cavities on the distal surface of canine. These are generally not used in incisors due to esthetic problems. Cavity preparation is started from the lingual marginal ridge. Box preparation is done toward the facial side. Axial wall is made tapered. The outline form which are generally adopted for Class III metal casting preparation are of three types:

1. Straight slot type with tapered retentive groove.
2. Slot type with fluted groove.
3. Step type with full lingual interlock.

Cavity preparation is extended to break the contact point but care should be taken to preserve tooth tissue at the incisal angle and labial wall. Some dentin should be left below the enamel on the facial side during box preparation in the proximal side. It is essential for the resistance form of tooth and to preserve esthetics. Least amount of tooth tissue is removed in the straight slot-

type cavity form with tapered retentive groove. Hence, these are indicated in the minimal carious decay. When the centric stops and stresses are falling on the restoration, then slot type with fluted groove preparation are made. Fluted grooves are placed on the greater bulk area of the tooth. When the caries destruction is very much, the step type with full lingual interlock preparation is made. This type of preparation reduces the chances of the incisal angle fracture. Retention may be supplemented in the proximal box with tapered grooves in the walls or in the cervical floor area.

### CLASS IV TOOTH (CAVITY) PREPARATION

Although it is not common, yet sometimes metal casting is given in class IV incisoproximal cavity in the anterior region. Such type of restorations are indicated where strength of the restoration is of primary concern.

Cavity preparation is started from the lingual surface and line of draw of the wax pattern is made incisally or slightly lingually. All the carious lesion is removed and the labial, lingual walls and gingival floor is placed on sound tooth tissue. Incisal preparation is made like a small box continuous with the proximal preparation. Cavo-surface margins are beveled. Retentive pinholes are made on the incisal area. Care should be taken during pinhole placement so as not to expose the pulp tissue. Sometimes slicing is done for better finish of restorations and to develop resistance form of the tooth.

### CLASS V TOOTH (CAVITY) PREPARATION

During cavity preparation, proper isolation especially retraction of gingiva is necessary to remove all the carious lesion and placement of cavity margin on the sound tooth tissue. Outline form of the cavity is trapezoidal, smooth flowing form without sharp angles where the mesial and distal walls meet with occlusal and cervical walls. Axial wall should be in dentin and of uniform thickness from pulp chamber.

Design of the cavity is given to obtain maximum retention form. Hence, pinholes are also given in the axial wall in the mesial and distal side of the cavity. Depth of the pinhole should be about 1.5 mm. Preparation of the cavity is completed by making continuous cavo-surface bevel.

## TOOTH (CAVITY) PREPARATION FOR CAST METAL ONLAY

These restorations are indicated where reinforcement of the cusps is required such as in cases where all the cusps of a posterior teeth are damaged or have become weak either due to carious process or previous faulty restoration and after pulpotomy or pulpectomy (Figs 29.15A to C)



**Fig. 29.15A:** Faulty amalgam restoration for root canal filled left mandibular first molar



**Fig. 29.15B:** Amalgam restoration reduced and crown prepared for onlay

### Tooth Cavity Preparation

At the time of carious removal, extent of the carious decay is important to decide type of restoration viz. inlay, onlay, crown. In cases where all the cusps are involved, onlay or crown is made.



**Fig. 29.15C:** Onlay cemented, finished and polished

- i. *Obtaining convenience form:* When the tooth is to be restored with an onlay, cusps are reduced to obtain proper convenience form. This improves both the access and the visibility for subsequent steps in cavity preparation. Occlusal divergence depends on the occluso-cervical depth of the preparation and is related to retention form of the prepared cavity. During cavity preparation, path of wax pattern withdrawal should be kept one and it should be parallel to the long axis of the tooth.
- ii. *Retention and resistance form:* On the occlusal surface 0.5 mm deep occlusal step in dentin is formed in the central groove region. Now the bur is moved mesially, distally, facially and lingually. In mesial and distal side also it should cross dentino-enamel junction. Mesial and distal extensions should be wider facially and lingually for proximal box formation. Extensions on lingual, facial and proximal sides have no modification, it should be just like inlay cavity preparation.
- iii. *Final cavity preparation for onlay and removal of remaining carious dentin:* After the initial cavity preparation on all the extensions on lingual, facial, occlusal and proximal surfaces, if any carious portion has been left, then it should be removed very carefully and a base is applied on the cavity floor. If the caries is deep and very near to the pulp then one mm thick layer of calcium hydroxide is placed before applying a base. Same procedure is followed if old, defective restorative material is removed.



### Bevels and Flares Preparation

After the placement of protective cement base (if indicated), retraction cords are correctly applied in the gingiva before bevels and flares preparation. A flame shaped, diamond bur is generally used for this purpose. Facial and lingual surfaces are counterbeveled by keeping 30 degree bur angle with the tooth surface. (Figs. 29.3 and 29.14) Counterbevels should be wide and placed enough gingivally so that no contact should be made with the opposing dentition. The exceptions for the counterbevel are facial cusp of maxillary premolars and first molar, because of esthetic reasons.

Gingival marginal beveling and flaring of the proximal enamel wall is same as inlay cavity preparation and has been described earlier. For further retention, the grooves are made in the facioaxial and linguoaxial line angles. Grooves should be within the dentin. Direction of preparation of the grooves should be parallel with the path of wax pattern withdrawal.

*Facial and lingual groove extension:* In order to provide extra retention, sometimes facial and lingual surface fissures in maxillary and mandibular molars are included.

### EXTENSION TO THE FACIAL AND LINGUAL SMOOTH SURFACES AFFECTED BY CARIES, FRACTURED CUSPS OR OTHER DAMAGES

All the carious and damaged portions/surfaces of the tooth, if it is within 0.5 mm of the cavity, may be on any surface, should be included in cavity preparation. Usually a shoulder is prepared perpendicular to the occlusal forces by involving the caries lesion adjacent to the fracture. This shoulder gives the resistance form by virtue of being perpendicular to gingivally directed occlusal force. The width of the gingival floor should be the diameter of the end of the cutting instrument.

### METHODS TO MAXIMIZE RESISTANCE AND RETENTION FORMS

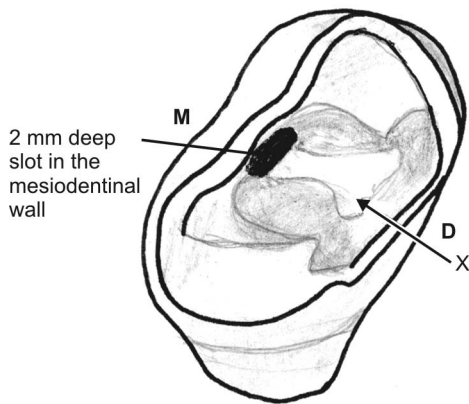
Modifications of basic onlays are as follows:

1. The minimal amount of taper (2 degrees per vertical wall)
2. The addition of proximal retention grooves
3. Preparation of facial and/or lingual surface groove extensions. There are three types of surface

extensions that may be superimposed on any type of cavity preparation. They are mainly prepared to increase retention and resistance form and to protect cusp from fracture:

- i. Skirt preparation
- ii. Collar preparation
- iii. Slot preparation.
  - i. *Skirt preparation:* Skirts are thin extensions of the cast metal onlay that extend from the primary flare to a termination. It is a conservative method to improve retention and the resistance form of the preparation. Skirts include part of the facial and lingual surfaces near the axial angle. For class I and class II preparation, depth should be 1 to 2 mm and for class III, class IV and class V preparation, depth should be 0.5 to 1 mm. The maximum depth of all skirts should be at the junction of the surface extension with the cavity preparation proper. The preparation of skirt is done entirely with the slender, flame shaped, fine grit diamond instrument usually only in enamel. Very little dentin may be rarely involved. Extending into the gingival third of the crown is usually necessary for effective resistance form. When skirt extension is done, over reduction of crown part is avoided (see Fig. 8.58B).
  - ii. *Collar preparation:* This type of surface extension increases resistance and retention form. The extension is done surface wise and depth wise. To provide for a uniform thickness of metal, the occlusal 1 mm of this reduction should be “rolled in” to follow the original contour of the tooth, to reduce the display of the metal and to conserve the tooth structure.
  - iii. *Slot preparation:* The use of a round or oval slot in the dentin is helpful (a) to provide the necessary retention, (b) to reduce the display of the metal, (c) to conserve the tooth structure, and (d) to reduce the marginal leakage by reducing the linear extension of the marginal outline. It can be prepared towards any surface. It is indicated only when enough thickness of dentin is available. Mainly distal and mesial slots are prepared. To prevent fracture of tooth, sharp line angles in the slot preparation are avoided. Such a slot is preferred over cutting a box in the distal or mesial surface because slot

is more tooth conserving and the linear extension of marginal outline is less (Figs. 8.58 and 29.16).



**Fig. 29.16:** Mesial slot for retention of D.O onlay in maxillary first premolar which has a cement base (M= Mesial Surface, D= Distal surface)

### Improving Esthetics on Maxillary Premolars and First Molars

To decrease the display of metal on maxillary premolars and molars, several modifications for esthetics are made to the basic onlay preparation. To decrease the display of metal, reduction of the tooth should not increase 1 mm on the facial cusp ridge of maxillary premolars and on the mesiobuccal cusp of the maxillary first molar. For rigidity, the thickness progressively increases toward the center. When more extension is to be done for removal of caries or previous restoration, then for esthetic reasons it is better to place a composite insert in between the tooth structure and the onlay at the margin to eliminate the visibility of the metal.

### Root Canal Filled Teeth

Root canal treated teeth become brittle after few months. For this, the remaining tooth structure is protected from any injury and fracture. Mainly posterior teeth are affected because of the masticatory force. Before starting the preparation of a root canal treated molar, the pulp chamber should be excavated to the chamber floor and amalgam foundation is placed. This amalgam gives a firm base for onlay. The root canal treated premolars are prepared for cast metal post in the root canal for additional retention. This post also gives support to restoration and tooth structure, otherwise horizontal fracture to the whole tooth may occur.

### Restoring the Occlusal Plane of a Tilted Molar

The onlay that covers all cusps is best for restoring the occlusal plane of a tilted molar. Normally for distal tilt mesiofacial and mesiolingual and for mesial tilt distofacial and distolingual margins are well extended on facial and lingual surfaces that recontour the proximal surfaces to desirable proximal surface contour and contact. The extension minimizes the loss of tooth structure by preparing facial and lingual skirt extensions on the respective proximal margins.

### Various Designs of Margins for Cast Restorations

The designs of margins for cast restorations are very important for successful restorations. Various designs are made but among them commonly used are bevel, chamfer, shoulder with bevel (Fig. 29.14) (For details refer Chapter 39).

## TECHNIQUES FOR MAKING CAST METAL RESTORATIONS

### Interocclusal Records

The occlusal contacts in maximum intercuspal position and in all lateral and protrusive movements must be evaluated before and after tooth preparation. The impression of the prepared and adjacent teeth is made by use of an elastomeric impression material that show in the die both the prepared tooth structure and adjacent teeth relationship. The occlusal relationship with the opposing arch teeth may be recorded with the occlusal anatomic contours. Alginate hydrocolloid are mostly used for the impression of opposing arch and rubber impression material are used for the impression of prepared arch.

The simple hinge type articulators are enough for some simple inlay restorative procedures. If the patient has sufficient canine guidance to provide disocclusion of the posterior teeth, then registration of opposing teeth is done by two methods:

1. Making a maximum intercuspal position interocclusal record of wax.
2. Making full arch impressions and mounting the cast on a simple hinge articulator.

When restoring a large portion of the posterior occlusion with cast metal restorations, the semi-adjustable articulators are used. Final adjustments in centric occlusion and various mandibular movements

are made in the mouth before cementation to assure complete functionally harmonious restorations.

### Temporary (Interim) Restorations

For the time period between tooth preparation and cementing the restoration, the tooth is protected and stabilized and the patient is made comfortable by providing temporary (interim) restoration made up of resin on the prepared tooth.

The temporary restorations should have the following properties:

- a. Non-irritating
- b. Protect and maintain the health of periodontium
- c. Provide esthetics
- d. Easily cleansable
- e. Adequate strength and retention to withstand the light masticatory forces.

Temporary restorations made up of acrylic resin can temporarily satisfy these requirements if properly made. They can be made by indirect and direct methods. Indirect method is preferred over the direct because in indirect method, temporary restorations are fabricated outside the mouth using a cast. Some main advantages of indirect technique over direct technique are as follows:

1. Marginal accuracy of indirect is better than the direct technique
2. Acute pulpal and soft tissue irritation from the monomer in resin and thermal irritation from the exothermic reaction cannot take place in the indirect technique as polymerization takes place outside the mouth.
3. Resin cannot be locked on preparation surface of tooth in small undercuts and in root area.
4. Chair time is reduced because a dental auxiliary makes the temporary restorations.

## TEMPORARY RESTORATION MAKING TECHNIQUE

### Indirect Technique

1. Make preoperative alginate impression before preparation of the tooth called impression no. 1. Preserve this impression in humid conditions by covering with wet cotton.
2. Make an impression of the prepared tooth with alginate called impression no. 2

3. Pour the impression no. 2 with fast setting plaster
4. When the cast is made, inspect the cast for any defects. Remove the defect and apply cold mold seal separating media over the prepared tooth and about 5 mm around it.
5. Mix tooth-colored acrylic resin and put it on preoperative alginate impression called no. 1 only in the prepared tooth area.
6. Now carefully seat the cast prepared by impression no. 2 in the impression no. 1 for shaping of the resin making temporary restoration.
7. Excess resin can be removed from the facial and lingual embrasure areas.
8. Remove the cast after resin is cured. Take out resin crown from impression no. 1.
9. Finishing of temporary restoration is done.

### Direct Technique

In this technique, the preoperative alginate impression is made:

1. The tooth is prepared.
2. Tooth colored self cure acrylic resin is put in the preoperative alginate impression in the prepared tooth area.
3. Impression is put onto the prepared tooth and removed after resin is cured
4. Finishing is done

*Advantage:* It is less time consuming.

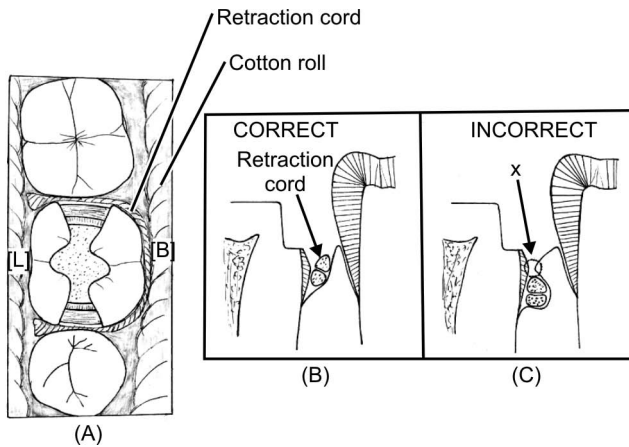
*Disadvantage:* Heat produced by direct polymerization of the acrylic and its monomer may irritate the pulp and periodontal tissues.

*Retraction of gingiva:* Before taking the impression the gingiva is retracted by the retraction cord so that proper impression of the gingival step/margin can be made (Fig. 29.17).

## FINAL IMPRESSION FOR CAST FABRICATION

Requisites for material used for final impression are as follows:

1. It must become elastic after placement
2. Strength should be adequate
3. It should have adequate dimensional accuracy, stability and reproduction of details.
4. Following impression materials are used for final impression:



**Fig. 29.17:** Inserting the retraction cord to widen the gingival sulcus for exposing gingival margin (A) Long enough cord to run from one gingival margin to another can be inserted but where margin is not subgingival as on lingual surface (L) cord should not be inserted, (B) Correct application of retraction cord, (C) Incorrect application of retraction cord causing impression material to tear at x. [B = Buccal, L = Lingual]

- i. Polysulfide
- ii. Silicone (polyvinyl siloxane impression)
- iii. Polyether impression materials
- iv. Agar.

All of the above materials provide adequate clinical accuracy.

## WORKING CAST AND DIES

### Die Materials

Dies should replicate the tooth preparation in the most minute details as well as all accessible unprepared area of the tooth. The die and cast materials should be compatible with the impression materials, and should have a smooth non-abradable surface.

1. *Gypsum:* The material used to fabricate the die and working casts are usually gypsum products. The smallest dimension that a gypsum product can reproduce is a groove having width of 0.050 mm.
2. *Resin die materials:* They are basically epoxy resin. They are supplied in two or three parts that are mixed before insertion into the impression. They are mixed just before using the material. They can

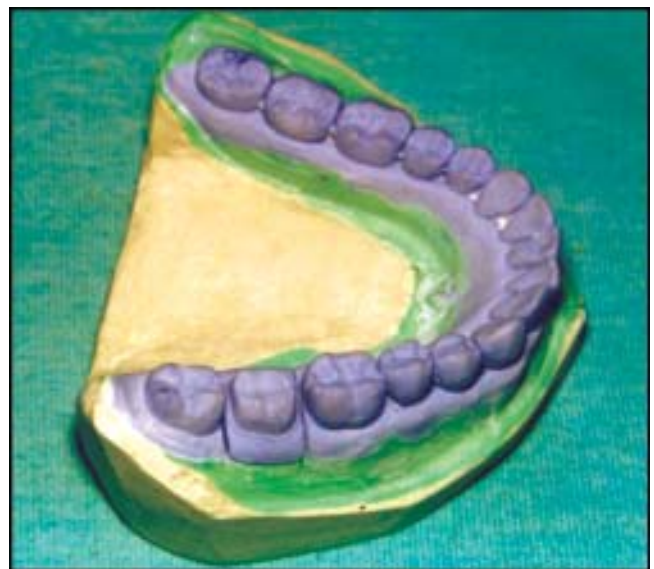
be poured into any type of impression, and provide correct details with all types of impression materials except the hydrocolloid impressions. The abrasive resistance, other strength and properties of resin die materials are far superior to gypsum die materials. Reproduction of details is much better than that of gypsum products.

Working cast is an accurate replica of the prepared and adjacent unprepared teeth over which cast metal restoration can be fabricated. Type IV or V stones are used for making dies and casts because they have superior properties. Twice pouring of cast is required for making a working cast with removable dies from an elastic impression. The first cast is used to prepare removable dies and the second cast is used to establish intra-arch relationship called 'master cast'. The casts thus prepared are known as split casts (Figs 29.18 and 29.19).

Several satisfactory methods are available for making a split cast. The strip technique is more suitable.

Advantages of the strip technique are as follows:

1. In this die (dowel) pins are positioned in the center of the die base.
2. Concave die is provided by this.
3. Without the use of rotary instruments or saws, speedy separation of the dies can be done.



**Fig. 29.18:** Master cast with removable individual die of the prepared tooth



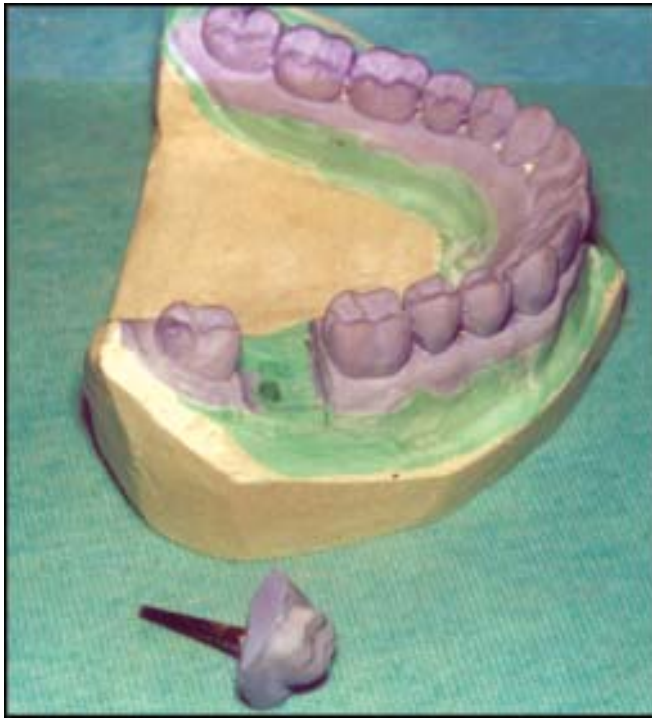


Fig. 29.19: Master cast and removable die shown separately

### Wax Pattern Fabrication

There are two methods for wax pattern fabrication:

- A. *Direct wax pattern method*: In which it is prepared in the oral cavity.
- B. *Indirect wax pattern method*: In which it is prepared out of the oral cavity

#### Direct Wax Pattern Method

Direct wax pattern produces better fitting than indirect method. Direct method is possible only in inlays and onlays and is not possible in crowns and bridges etc. In direct method wax pattern is prepared as follows:

1. For this, type I inlay wax is used.
2. Inlay wax is sufficiently softened by heating and rotating it over a smokeless alcohol flame.
3. Soft inlay wax is compressed into the cavity for few minutes with finger pressure. This technique is called 'compression technique'.
4. Cooling of wax to the mouth temperature results in contraction. This contraction is compensated by holding the wax in the cavity under finger pressure until it reaches mouth temperature.

5. Excess of wax is removed and carving is done.
6. Patient is asked to bite in centric occlusion for a few seconds after placing a thin layer of cotton fibers soaked in warm water.
7. Occlusal surface is examined for high spots which should be removed and carved.
8. After removing high points from occlusal surface, all the margins of the pattern are examined and corrected.
9. After satisfactory wax pattern formation the sprue former and reservoir is attached to the thickest point of the wax pattern.
10. Wax pattern is removed from the cavity and carefully examined for marginal integrity.

#### Indirect Wax Pattern Method

In indirect method wax pattern is prepared as follows.

1. Type II inlay wax is used for indirect wax pattern
2. Die is lubricated by any lubricating fluid. The lubricator should produce a very thin separator film.
3. The inlay wax is adapted to the die by flowing or by the compression technique.
4. Carving is done by a warm instrument
5. Sprue former is attached to the wax pattern to the thickest portion as in direct method.

#### Spruing, Investing and Casting

1. Sprue pin or sprue former provides a channel for flowing the molten metal.
2. For small casting, a metallic sprue is attached.
3. Hollow sprue pin filled with inlay wax is better because it provides stronger attachment to the wax pattern.
4. Sprue is attached into the bulk portion of the pattern
5. The pin should be placed at an angle to the surface and should be attached to the thickest area.
6. Ideal locations to attach the sprue pin are the marginal ridges of posterior teeth or incisal corners of anterior teeth.

#### Washing of Wax Pattern

Before investment the wax pattern is washed with soap and water with the help of a soft no. 1 or 2 pointed hair brush to remove the oil, lubricant and saliva. This will help to reduce surface tension and the air bubbles on the surface of wax pattern, thereby reducing bubbles on the casting.

**Investing**

1. The wax pattern is surrounded by an investment that hardens and forms the mold in which the casting is made.
2. There are two main methods of investing the wax pattern:
  - a. Hand investing
  - b. Vacuum investing.

**Casting Procedure**

It includes the burnout for wax elimination, expansion of the investment to compensate for casting shrinkage and placement of the gold alloy into the mold. There are various types of casting machines. Centrifugal casting machine is very popular and cheapest in cost, giving reasonably good results for small castings, hence is described here (Fig. 29.20).



**Fig. 29.20:** Centrifugal casting machine for gold castings

The sequence to be followed in gold alloy casting is as follows:

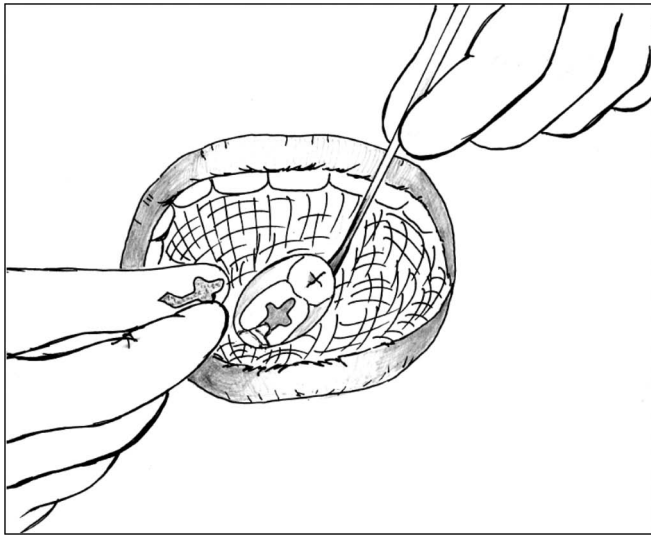
1. Heat the ring in which wax pattern has been invested to 1200°F (648.9°C) and keep it at this temperature for 15 minutes in the furnace. This is to make certain that the mold is fully prepared and contains no residue.
2. Rotate arm of the casting machine by 2 to 3 turns (depending on the size of the casting) in clock-wise direction and lock it so that the arm does not rotate back.
3. Heat the gold alloy in the crucible of the casting machine until it becomes bright orange in color and has a shiny appearance.
4. Place the casting ring in the cradle of the casting machine. The end of the ring with the sprue way should be towards the crucible. Move up the crucible as close as possible to the casting ring.
5. When the gold alloy is fully melted release the lock of the casting arm to force the liquid gold into the mold by centrifugal force.
6. Remove the ring from the casting machine and keep it in the water keeping sprue end upward and above the water level, and dry, till the ring is cooled.
7. Recover the casting and scrub it to clean it with a bristle toothbrush and water, to remove investment from the casting.

**Finishing, Adjusting and Polishing the Casting**

1. Internal and external surfaces should be closely examined.
2. Rough casting should be refined before trying onto the prepared tooth or the die.
3. The casting should go in place with little or no pressure. Forceful attempts can cause irreparable damage to the die or tooth.
4. Final occlusal morphology is determined by interocclusal adjustment.
5. Occlusion is checked by articulating paper and premature contacts are removed.
6. After removing the premature contacts, the surface is finished with rubber cup and mild abrasive points.
7. Proximal surfaces should be finished with felt wheel and polishing compound.
8. After smoothening, the casting is polished to make it resistant to tarnish and corrosion.
9. Intra oral finishing can be done by intraoral sand blaster (see Fig. 21.9).

**Trying-in the Casting in the Oral Cavity**

1. Before the 'trying in' procedure, temporary restoration and cement should be completely removed and no trace of it should remain in the cavity.
2. Before trying in, a four layered gauze piece is used as a throat screen during trying-in and removal of small indirect restoration till the cementation of the casting (Fig. 29.21).
3. Try the casting on the tooth using light pressure. If it does not seat properly do not force it in the cavity.
4. Cause of not seating the casting may be over contouring of the proximal surface. This should be judged with the help of a mouth mirror and a good spot light. Examine the embrasures and judge the points where proximal recontouring is required.



**Fig. 29.21:** Four layered gauze piece is used as a throat- screen during try-in and removal of small indirect restorations

5. Dental floss is passed through the contact to find out the tightness of the contact and its locations.
6. In MOD restoration, if both the contacts are tight then adjust the first one which is more tight and then try the restoration again in die or in the mouth. Because one excessive tight contact can give the feeling as if the other contact is also tight.
7. Fine carborundum particles, impregnated rubber discs or wheels are best for adjusting the proximal contact and contours.
8. Patient should not feel much tightness or pressure between the teeth after final adjustment of the contact points.
9. Contact should be prepared by soldering the 'solder' at a proper place if there is no contact.

### Contact Building by Soldering

1. Contact area of the casting is cleaned.
2. Very mild dilute acid is applied to the contact area for further cleaning.
3. Cut a small piece about 2.0 to 3.0 mm in diameter of solder out of strip of solder for the gold alloy which has been used for casting.
4. Borax type flux is applied on the contact area of the casting and on both the surfaces of the piece of solder.
5. Place the solder at proper place on the contact area to be build up.

6. Direct the pinpoint flame of bunsen burner to the solder with the help of blow pipe.
7. The temperature should rise slowly. The flame should not be directly applied to the parts to be soldered until the flux has melted and has formed a uniform layer.
8. The flame is directed to the solder little longer to increase the temperature so that the solder melts and flows.
9. Soldering should be completed in the shortest possible time.

### Cementation

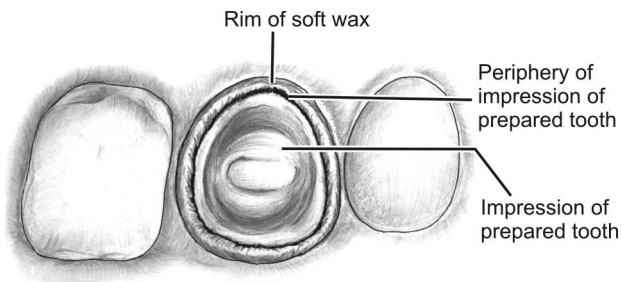
1. The casting should be cleaned thoroughly before cementation.
2. The prepared tooth is isolated, cleaned and a thin layer of varnish is applied in the preparation.
3. Warm air should be applied to the gingival sulcus of the prepared tooth to dry it.
4. Thin layer of cement is quickly applied on the surfaces of the casting which will be in contact with the tooth surfaces.
5. Finally place the thin layer of cement on all tooth preparation surfaces.
6. The casting is seated with the help of hand force through a suitable instrument.
7. After assuring complete seating of the casting, the patient is asked to bite on a small cotton pellet which is placed on the occlusal surface of the casting.
8. After the setting of cement the area is cleaned with dry cotton for removing of the remnants of set cement.
9. Occlusion is rechecked for harmony of centric occlusion
10. Gingival sulcus is carefully checked and all particles of cement are removed to avoid irritation to the supporting tissues.

### Removable Die Formation

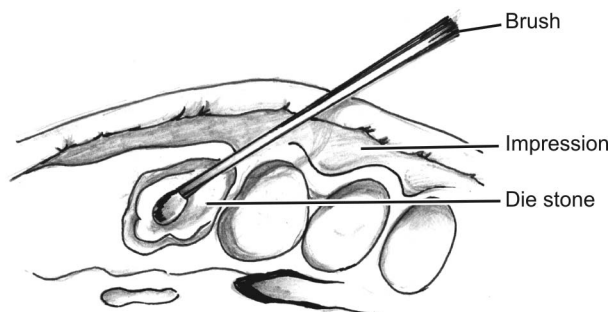
For accurate die formation, impression material and die stone must be used as per the instructions of the manufacturer. All impressions with the exception of those made from addition silicone should be casted within 30 mts. after removal from the mouth. After taking the impression, to locate the margins of the preparations correctly on the die a thin rim of soft utility



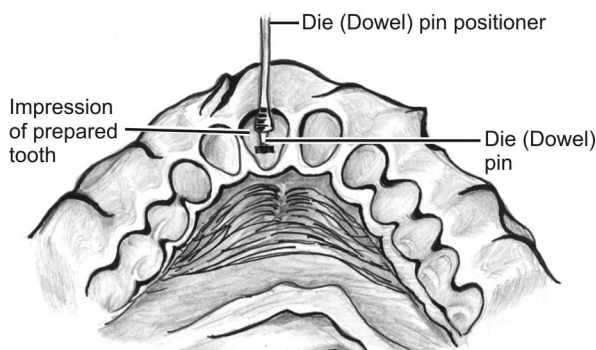
wax is placed just outside the finish line of the preparation before the die is casted. (Fig. 29.22). When the die stone is forming the coronal portion of teeth, it should be flown into the impression in small increments. The stone is carried to the impression with a no 1 or 2 sable hair bush (Figs. 29.23 to 29.25).



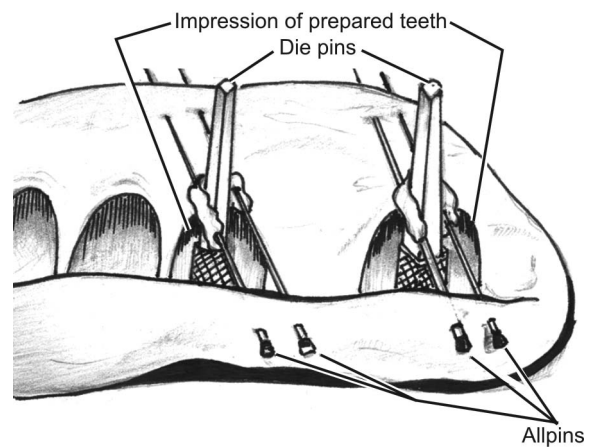
**Fig. 29.22:** To facilitate die preparation and location of margins of preparation a 'rim' of soft wax is adapted to the tissue side of the impression right at the finish line of the preparation



**Fig. 29.23:** A brush is used for placing the die stone in the impression of the prepared teeth to prevent air bubbles or voids



**Fig. 29.24:** A die (dowel) pin is being placed in position with the help of 'pin positioner' in the impression of the preparation



**Fig. 29.25:** Two die pins held in the positions with the help of allpins

### Die (Dowel) Placement

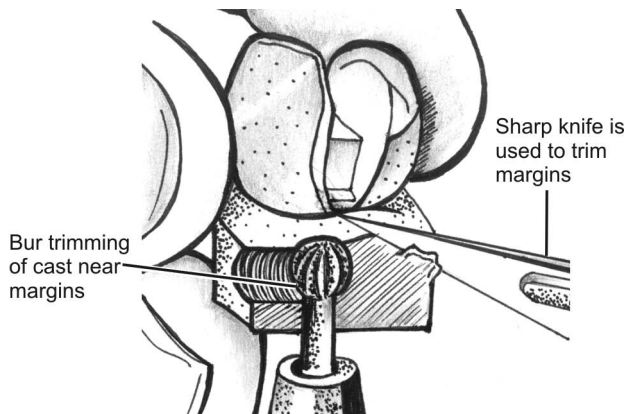
For proper building, carving, contouring and finishing the proximal sides of the casting it is necessary to isolate and remove each die from its surroundings. Die pins are made up of brass or any other non-rusting metal alloy. The die pins are used as a means of orienting dies to the master cast. These pins allow the dies to be easily removed and accurately replaced into 'master' cast. These pins are tapered and cylindrical but flattened on one side for correct reseating. The thicker end called 'head' has serrations so that the pin can be securely held in the dies (Fig. 29.24). On the vibrator the impression with tray is held at angle of 10 to 20 degree. This allows the stone to flow easily and continuously from the same direction to eliminate or reduce the air bubbles. The impression is filled only upto about 1/2 cm above the impression of the prepared crown of the tooth. The coronal portions and the head of die pin should be fully embedded. Die pins (dowel pins) are placed one each for prepared crown parallel to the long axis of the tooth. The dowel die pins are suspended in impression over the preparation area by the help of dowel pin 'positioner' or 'holders' which are used to hold the pins in upright position. These pins are positioned so as to be parallel to the long axis of the tooth and they will be able to move easily in and out of the master cast (Fig. 29.24).

The dowel (die) pins can be positioned in the impression by straight allpins parallel to each other

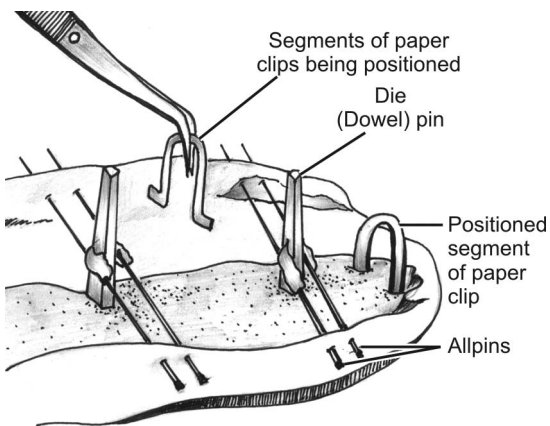


### 302 Textbook of Operative Dentistry

through the flanges of the impression so as to allow the dowel pins to be held between the two pins slightly above the impression of the prepared tooth. The dowel pins are stabilized into position between the allpins by flowing sticky wax around the junction area. The die stone is vibrated into the impression. The impression of the prepared teeth and the area around them is filled with the die stone (Figs 29.25 to 29.28).



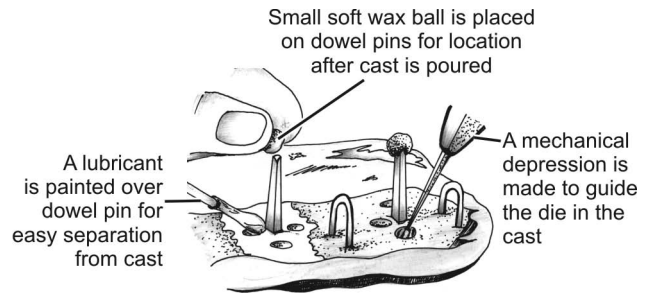
**Fig. 29.26:** Trimming of margins of the die



**Fig. 29.27:** Segments of paper clips are positioned to secure the second portion of the cast for making removable dies

As soon as the die stone set the individual die is taken out of the impression and finished.

Another fresh impression is taken of the same arch. The already prepared and finished die with die pin is coated thoroughly with separating media and placed at a proper place in the second impression. The die pins are kept and held parallel to the long axis of the tooth. This



**Fig. 29.28:** Orientation of the portions of the cast for making removable dies

impression is poured with die stone or dental stone to make 'master cast'. To mechanically secure the addition of die stone to second impression after placing die, paper clips are cut and the curved portion is placed into the first pour of the die stone before it sets (Fig. 29.29).



**Fig. 29.29:** After placement of die pins, die stone is vibrated into the impression

In this method two segments of the casts are secured properly. To prevent rotation of the die when it is seated into the master cast a depression with no.4 bur is made in the set stone. A lubricant is painted over the die (dowel) pin for easy separation from the cast. The area to be included in the die is covered by a separating material to prevent the die from sticking to the master cast. To help in locating the tail ends of the die pins they are covered with a small ball of soft wax before pouring the final part of the stone.

After final setting of the stone for few hours, 'dies' are carefully separated from the master cast. For this purpose a fine laboratory saw with thin blade may be used. The wax balls over the tail ends of the pins are located and by applying pressure on the end of the dowel pins the dies are occlusally moved out of the master cast. For more accurate results upper and lower full

arch casts should be prepared which occlude together. The cast should be articulated on an articulator. The casts may be occluded on the basis of wear facets which should coincide with each other for a single restoration. For several restorations or if the wear facets are not easily detectable, it is essential to use an occlusal registration to articulate the casts in proper relation (Fig. 29.30).

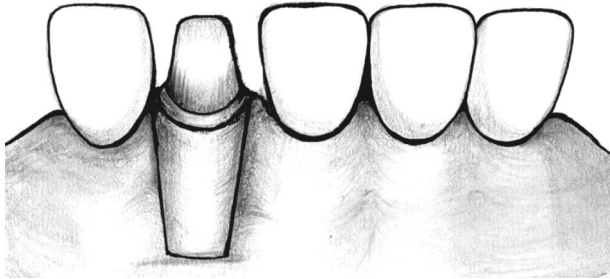


Fig. 29.30: Removable die in position

## PIN RETAINED CAST RESTORATIONS

Pins are means of additional retention. Preparations for cast pin channels are wider and are with slightly divergent walls than the pin holes used for pin retained amalgam restorations. The cast pin channels are prepared by tapering fissure bur having a diameter of about 1 mm with the depth of about 2 to 3 mm. If more than one pin channel is to be prepared the strict parallelism between them must be maintained.

### Indications for Pin Retained Cast Restorations

Pin retained cast restorations are used to supplement the retention which is required in the following conditions:

1. Cuspal fractures where large occlusal inlays and onlays are to be prepared.
2. When occluso-gingival height is very short for example in severely attrited and abraded posterior teeth.
3. When crown preparation is excessively tapered, leading to reduced retention.
4. In full crown preparation when one wall is very short and another wall is very long. Pin channel is prepared toward the shorter wall.
5. When the proximal preparation is very long. The pin channel is prepared at the other end of occlusal lock.

6. The proximal box of the preparation having one wall very short and opposing wall very long. The pin channel is prepared towards the shorter wall.

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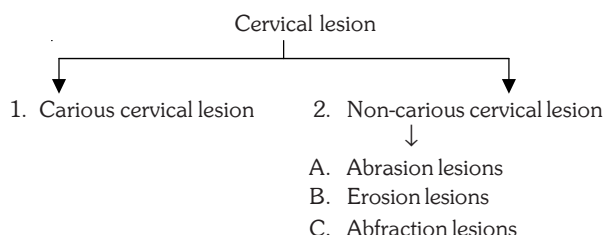
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Certain changes in the dental tissues include a variety of alterations that are etiologically and pathogenetically different from caries. More than seventy percent cervical lesions are among them. They are more present in aged persons. Some arise as a result of continuous mild injury to the hard tooth tissues, while others may be due to caries. Cervical lesions are due to loss of hard tooth tissue at the cemento-enamel junction or usually in its one-third portion of tooth crown and root. These lesions are included in class V cavities which according to GV Black may be defined as 'cavities found at the gingival third of the facial and lingual surfaces of anterior and posterior teeth'.

Cervical lesions may occur either due to caries or may be non-carious lesions which include abrasion, erosion and abfraction.

## CLASSIFICATION OF CERVICAL LESIONS

Classification of cervical lesion is basically based upon the etiology of the lesion.



### 1. Cervical Lesions Due to Caries

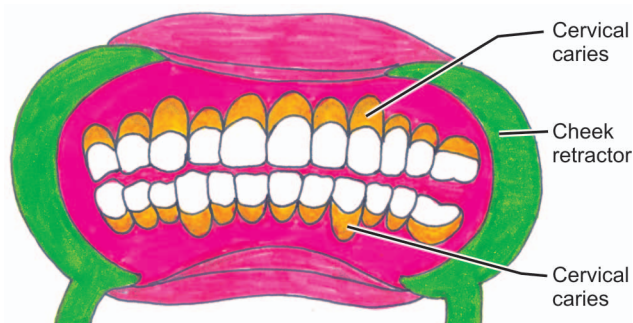
Cervical carious lesions are smooth surface carious lesions. Patients undergoing radiation treatment for malignancy of the organs of the oral cavity and the jaw bones frequently show advanced rampant carious cervical lesions (Fig. 30.1). They have a broad area of origin and a conical or pointed extension towards DEJ. The path of ingress of the lesion is roughly parallel to the long axis of enamel rods in the region. A cross

section of the enamel portion of the lesion shows a 'V'-shape with a wide area of origin and the apex of 'V' directed towards pulp. After caries penetrates the dentino-enamel junction, softening of the dentin spreads rapidly pulpally and may also spread laterally. Carious cervical lesions are usually seen in the region of plaque accumulation, i.e. near the gingival or under proximal contacts. The lesions may be shallow saucer shaped or deep notch shaped (Fig. 30.2).

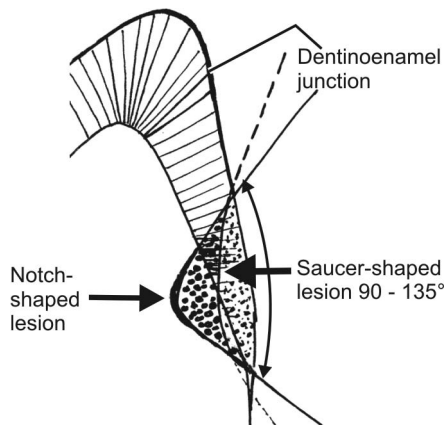
Often the gingival aspect of facial and lingual smooth enamel surfaces that is supragingival but gingival to the occlusogingival height of contour, is neither rubbed by the bolus of food nor cleaned by the tooth brush. Therefore, these surface areas are habitats for caries producing mature plaque. The presence of caries in these areas usually is indicative of a caries-active mouth.

### 2. Non-carious Cervical Lesion

Non-carious cervical lesions can also be described as 'wasting disease of the teeth' which can be defined as any gradual loss of tooth structure characterized by the formation of smooth, polished surfaces, without regard



**Fig. 30.1:** Advanced rampant carious cervical lesions in aged patient having receded gums who had radiation treatment for malignancy of jaws



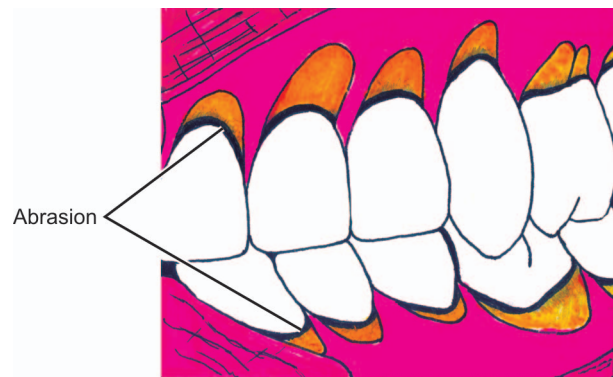
**Fig. 30.2:** Class V cervical defect comparing saucer-shaped lesion to notch-shaped lesion. Angulation is not determined by walls perimeter of lesion

to the possible mechanism of this loss. They include abrasion, abfraction, resorption, etc. among which abrasion, erosion and abfraction are usually responsible for inducing cervical lesions. These lesions are usually associated with general aging process of the individual while some arise as a result of injury to the tissue. These lesions cannot be regarded as developmental abnormalities or as inflammatory lesions, rather they are considered as regressive alteration of the teeth. These lesions present a variable morphology ranging from shallow grooves to broad dished out lesions, to large notched or wedge-shaped defects.

### A. Abrasion Lesions

Abrasion is pathologic wearing away of tooth substance through some abnormal mechanical process. It refers to the loss of tooth substance induced by mechanical wear other than that of mastication. Abrasion results in saucer-shaped or wedge-shaped indentations with a smooth, shiny surface. It usually occurs on the exposed root surfaces, but under certain circumstances it may be seen elsewhere, such as on incisal surface in pipe smokers and tailors holding needle with anterior teeth or on proximal surfaces. Most common cause of abrasion is use of abrasive dentifrice. Continued exposure to the abrasive agent, combined with decalcification of enamel by locally formed acids, may result in loss of enamel, followed by loss of the dentin. Wrong method of tooth brushing with hard brush with abrasive dentifrices and the action of hard metallic clasps

are also common cause of abrasion. The degree of tooth wear from tooth brushing depends on the abrasive effect of dentifrice and the angle of brushing. Horizontal brushing at right angles to the vertical axis of the teeth results in the severest loss of tooth substance. Unless the form of abrasion is an extremely severe and rapidly progressive one, the rate of secondary dentin formation is usually sufficient to protect the tooth against pulp exposure (see Fig. 31.4). Cervical abrasive wear on the proximal surface of teeth is often caused by friction from objects such as toothpicks, inter proximal brushes, etc. (see Figs 27.1 and 30.3).



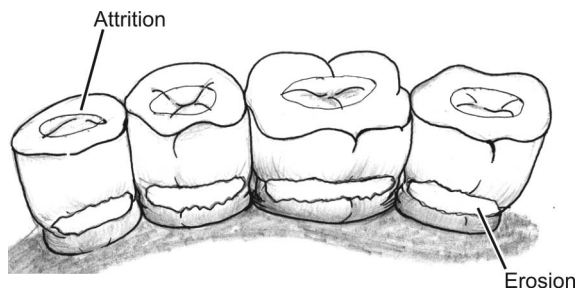
**Fig. 30.3:** Abrasion due to aggressive tooth brushing showing wedge shaped indentations. Roots are also involved undermining the enamel

### B. Erosion Lesions

Erosion is sharply defined wedge-shaped or irregular depressions caused by chemicals in the cervical area usually on the facial tooth surface. It can also be defined as a loss of tooth substance by a chemical process that does not involve known bacterial action. The long axis of eroded area is perpendicular to the vertical axis of the tooth. The surfaces are smooth, hard and polished. Although generally confined to the gingival third of the labial surfaces of anterior teeth, erosion may affect the labial surfaces of any teeth. The lesions, which may exhibit considerable variation in size and shape, usually involve several teeth. The etiology of erosion is not known. Decalcification by acid beverages or citrus fruit and the combined effect of acid salivary secretion and friction are suggested causes. Erosion or gastric acid decalcification of teeth is a common finding in patients with anorexia nervosa. This is a psychosomatic disease



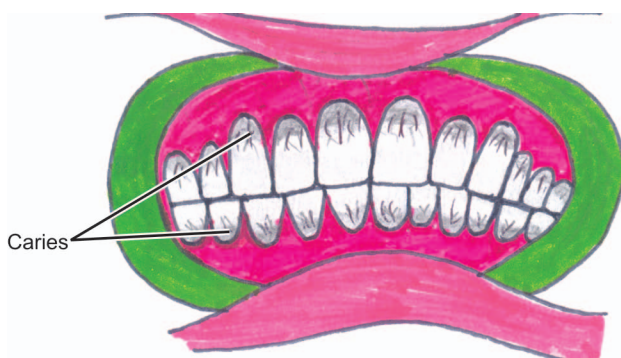
mainly affecting young women. Erosion may be localized or generalized (Fig. 30.4).



**Fig. 30.4:** Severe occlusal attrition and localized cervical erosion

### C. Abfraction Lesion (Idiopathic Erosion)

These are microfractures which appear in the enamel as cervical area of tooth flexes under heavy loads. These are minor irregular cracks or fracture lines or wedge shaped defects in the cervical region of the tooth. They may result due to excessive masticatory forces on the teeth due to malocclusion. They are most commonly seen on the buccal surfaces of mandibular teeth. It is a wedge shaped lesion with sharp line angles and are present in the area of greatest tensile stress concentration. In patient with bruxism habit caries is superimposed on abfraction lesions in anterior teeth (Fig. 30.5).



**Fig. 30.5:** Caries developed in abfraction lesions caused due to bruxism

## MANAGEMENT OF CARIOUS CERVICAL LESIONS

Abfraction lesions in cervical area of lower teeth. The cervical lesions occurring due to caries may be restored

using various restorative materials. However, depending upon the extent of lesion, i.e. if only superficial, treatment may be restricted to simply employing preventive measures, as they may successfully limit the lesion without the need for elaborate restorative modalities.

### Preventive Management

All the preventive measures for the caries control should be taken under consideration while going for the preventive management of carious cervical lesion. Patient should be advised to eliminate or reduce refined sugars from his meals. Plaque control measures should be taught to the patient along with proper toothbrushing technique. Scaling to remove deposits from the teeth should be performed and patient is advised to rinse the mouth with chlorhexidine mouthwash. Topical fluoride application is done for increasing the resistance of tooth surface to demineralization and promoting remineralization.

### Restorative Management

Under such conditions where caries had decayed a tooth to such an extent, that preventive measures become useless then the restoration of the tooth is done with the help of various restorative materials. Although the type of cavity prepared for restoring a cervical lesion is class V for all restorative materials, there are certain modifications in cavity design for different restorative materials.

Earlier, the filling materials used for restoration of class V cavities were silver amalgam, direct filling gold and porcelain. However, due to increasing esthetic demand, composite resins, glass ionomers, resin modified glass ionomers are the material of choice. However, where esthetics are not of much concern like in posterior teeth the material of choice for restoration is silver amalgam and direct filling gold management of carious cervical lesions using various restorative materials.

### Restoration of Cervical Lesions using Composite Resins

Composite resins are most commonly used restorative material for restoration of cervical lesions. Usually they are used as direct filling tooth colored restorative materials. Composites are presently the most popular tooth colored materials, having completely replaced silicate cements and unfilled acrylic resins. Basically,

composite restorative materials consist of a continuous polymeric or resin matrix in which an, inorganic filler is dispersed. This inorganic filler phase significantly enhances the physical properties of the composite by increasing the strength of the restorative material, reducing polymerization shrinkage, marginal leakage and the linear coefficient of thermal expansion. Composites are usually divided into three important types based on the size, amount, and composition of the inorganic filler: (i) Conventional composites, (ii) Microfilled composites, and (iii) Hybrid composites.

Of the above three types of composites, microfilled composites are the material of choice for restoration of cervical lesions as they are clinically very much wear resistant. Also, their low modulus of elasticity may allow microfilled composite restorations to flex during tooth flexure, thus better protecting the bonding interface. Thus, they are appropriate choice for restoring class V cervical lesions or defects where cervical flexure can be significant (e.g. bruxism, clenchers, stressful occlusion).

Tooth (CAVITY) preparation for composite restoration :

- Remove the defective, friable tooth structure.
- Create prepared enamel margin of 90 degrees or greater (greater than 90 degrees are usually preferable on crown portion of teeth).
- Create 90 degrees (or butt joint) cavosurface margins on root surface.
- Roughen the prepared cavity surface.

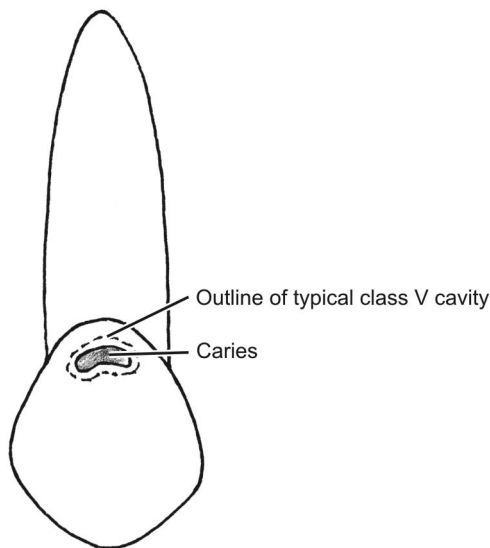


Fig. 30.6: Caries in cervical area on labial surface

Although cavity preparation had been described previously in the chapter of composites in detail here, few points have been described which must be remembered while preparing a class V cavity preparation (Fig. 30.6). The features of preparation include a 90 degrees cavosurface angle; uniform depth of the axial line angles, and, sometimes, groove retention form (Figs 30.7 to 30.10).

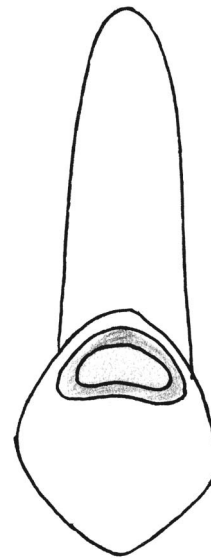


Fig. 30.7: Class V cavity conventional beveled preparation on enamel for composite

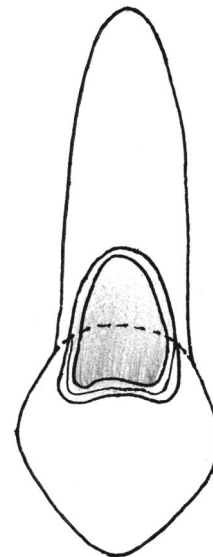
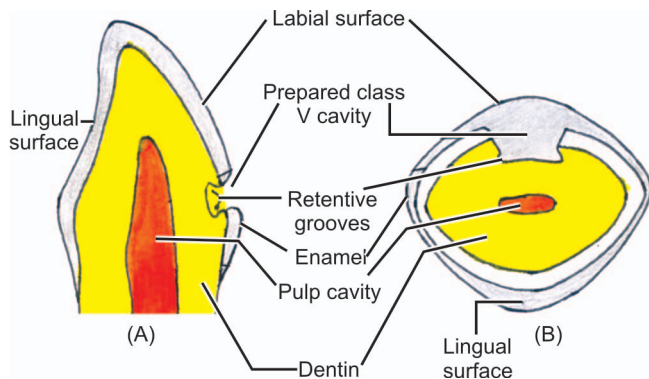
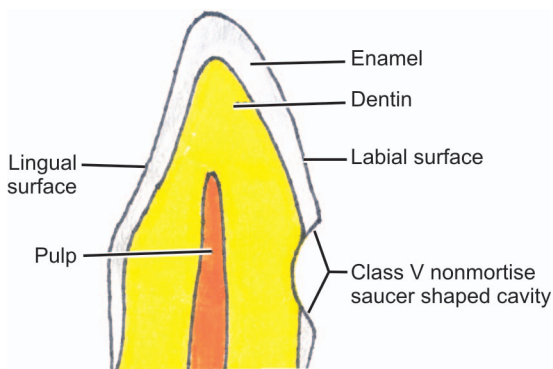


Fig. 30.8: Class V cavity preparation, extending on to root. Crown portion is beveled conventional. Root portion is unbeveled conventional



**Fig. 30.9:** Class V cavity with retention grooves (A) in labiolingual section of canine, (B) in transverse section of canine



**Fig. 30.10:** Class V Nonmortise saucer shaped cavity (in labiolingual section in canine). Indicated in sensitive erosion and abrasion cavity. Retention is obtained by etching and bonding

Basically, the following three designs for cavity preparation are made:

- Conventional class V tooth preparation: Indicated for that portion of a carious lesion or defect entirely or partially on the facial or lingual root surface of a tooth.
- Beveled conventional class V tooth preparation: Indicated either for the replacement of an existing, defective class V restoration that initially was used as a conventional preparation or for a large, new carious lesion.
- Modified (Conservative) class V tooth preparation: Indicated for the restoration of small and moderate class V lesions or defects.

Retention is achieved by placing retention grooves as in conventional design or by acid etching of enamel as in modified design.

### Restoration of Cervical Lesion using Glass Ionomer Cement

Glass ionomer cements can be used to restore cervical lesion. Though they are not esthetically as superior as composites but they possess the favourable quality of releasing fluoride when exposed to oral cavity. This property may render glass-ionomer restorations more resistant to recurrent caries, because of this potential anticariogenic quality, glass ionomer may be the material of choice for restoring root surface caries in patients with high caries activity and where accurate shade matching for esthetics is not very important.

Both self-cured and light-cured versions of glass ionomers are available. Resin modified, light-cured glass ionomers are preferred because of the following reasons: (a) The extended working time, (b) their improved physical properties, and (c) esthetic qualities.

Tooth preparation for glass ionomer cements is same as for composite restorations. GIC is considered as a dentin substitute, highly biocompatible and also bonds to different dental tissues.

### Restoration of Cervical Lesion using Silver Amalgam

Class V amalgam restorations may be used anywhere in the mouth, but they are generally reserved for the following areas:

- Nonesthetic areas,
- For areas where access and visibility are limited,
- Where moisture control is difficult, and
- For areas that are significantly deep gingivally.

Amalgam restorations usually serve for a long time without failing, also amalgam may be preferred over esthetic restorative materials on partial denture abutment teeth, because amalgam is more resistant to wear as clasps move over the restoration. Further as amalgam restorations are stronger they are generally easy to place and may be less expensive to the patient. Due to their metallic color, they should not be placed in esthetically important areas. Cavity preparation is same as that for class V conventional composite restoration.

### Restoration of Cervical Lesions using Direct Filling Gold

Pure gold has been used in dentistry since long time. The longevity of direct gold restorations is a result of both the superb biocompatibility of gold with the oral

environment and its excellent marginal integrity. They are indicated for restoration in small class V preparations.

### Management of Non-carious Cervical Lesions

One of the important steps for the treatment of non-carious cervical lesion is careful consideration of the etiology and progression of the condition. Etiological factors should be assessed by proper diagnosis. Without determination of the causative factors, there are chances of failure of treatment.

Management of non-carious cervical lesion is done in two phases, i.e. preventive and restorative.

#### Preventive Management

Removal of etiology is the prime aim of preventive management. Measures to control acid formation are undertaken. Other preventive measures include:

- a. Proper tooth brushing using soft bristle toothbrush with less abrasive dentifrices.
- b. Use of orthodontic appliances to prevent bruxism and clenching.
- c. Correct occlusal disharmony.
- d. Restrict acidic and acid producing diet.
- e. Correct ill-fitting metal clasps or denture.
- f. Topical fluoride application.

#### Restorative Management

Non-carious cervical lesion can be restored using either of the restorative material used for carious cervical lesion, i.e. composites, silver amalgam, glass ionomer or direct filling gold. Restoration of non-carious cervical lesion is important so as (a) to maintain the structural integrity of the tooth, (b) to protect pulp also (c) to maintain the gingival health, and (d) to prevent caries. Restoration of lesion is also necessary from esthetic point of view. Although any of the above restorative materials can be used, though the material of choice are composites or resin modified glass ionomer cements, as they require minimum tooth preparation and attain retention by forming a bond with tooth tissues. Also they have an advantage of being esthetically superior to other commonly used restorative materials.

The tooth preparation for a class V abrasion or erosion area usually requires only roughening of the internal walls with a diamond instrument beveling or flaring all enamel margins, and sometimes placing a retention groove in non-enamel area. Greater resistance to marginal leakage results from groove placement, because this retentive feature assists in resisting the effects of polymerization shrinkage and tooth flexure.

While restoring a cervical lesion, microleakage is a major problem which can lead to (a) staining, (b) post-operative sensitivity, (c) recurrent caries, (d) pulpal injury, and (e) accelerated deterioration of some restorative material. Glass ionomers were material of choice because they bond to different types of tooth structure and do not require any or minimum tooth preparation. Later resin based GIC (RMGI) came in use, which was highly esthetic and had better abrasion resistance than conventional GIC.

'Dyract', a polyacid modified composite resin is considered as an ideal class V restorative material by many clinicians. But the problem associated with dyract is that it could possibly not release enough amount of fluoride in cervically eroded area. Both glass ionomer and Dyract have definite potential to successfully restore cervical lesion and do not show clinically significant marginal leakage.

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## 310 *Textbook of Operative Dentistry*

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# Conservative Esthetic Procedures

**Esthetic** means pertaining to a sense of the beautiful.

## ARTISTIC ELEMENTS

Best conservative esthetic results can be obtained by the consideration of the following factors:

1. Shape or form
2. Symmetry and proportionality
3. Position and alignment
4. Surface texture
5. Color
6. Translucency
7. Defect and damage repair.

### Shape or Form

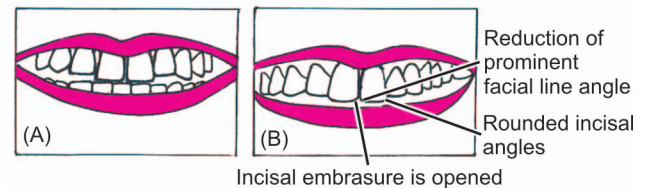
Every tooth in the arch has an ideal anatomic shape and form. There is also slight change in tooth form in male and female. Hence, actual information about the shape or form of a particular tooth is necessary before treating it to improve esthetics. For example, female tooth shows smaller size, rounded incisal angles, open incisal and facial embrasure.

If in females slightly broader teeth are present, then they sometimes require conservative minor modification to produce better esthetics. This is called 'Cosmetic contouring'. In such teeth, incisal angles are rounded, incisal embrasures are opened to produce more feminine and younger appearance (Fig. 31.1).

Generalized improved facial appearance is possible only when full coverage facing restoration such as laminate veneers are made. Restoration of a small portion of tooth as compared to full coverage facing requires less artistic skill.

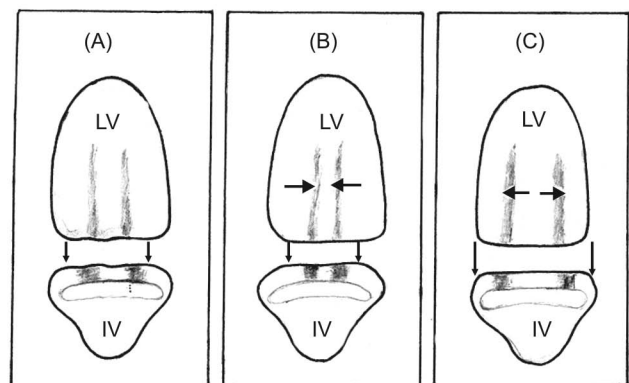
### Illusion of Shape or Form

Size of body is visible according to the light reflected from it. It depends upon the depth of the surface. Hence, it controls width and length which appear to a viewer.

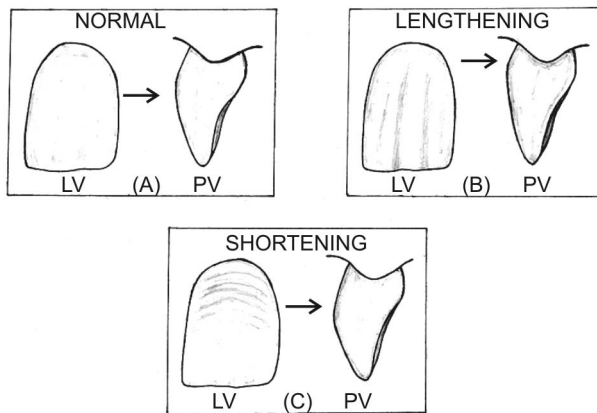


**Fig. 31.1:** Cosmetic contouring of anterior teeth (A) Before treatment, (B) After treatment, a more feminine, and youthful appearance is produced

When a tooth is highlighted upon direct light, then area of depression is shadowed and not very prominent. The tooth size which is to be appeared can be changed by creating different types of facial prominence. These illusions are useful for creating apparent size of a tooth which appears different from actual size. These are important at many places like diastema closure in which composite are placed in such a way that apparent total width of teeth appears unchanged [Figs 31.2 (A to C), and 31.3].



**Fig. 31.2:** Creation of illusions of width (A) Normal width, (B) Illusion of narrowness by positioning mesiofacial and distofacial line angles closer together and by more closely positioning developmental depressions, (C) Illusion of greater width by positioning line angles and developmental depressions further apart. LV = Labial view IV = Incisal view



**Fig. 31.3:** Creating the Illusions of length (A) Normal length (B) On moving gingival height of contour gingivally and emphasizing vertical elements like developmental depressions, the illusion of length is achieved. (Tooth appears longer) (C) Crown of a tooth can be made to appear shorter by emphasizing horizontal elements and by positioning the gingival height of contour further incisally. LV = Labial view PV = Proximal view

### Symmetry and Proportionality

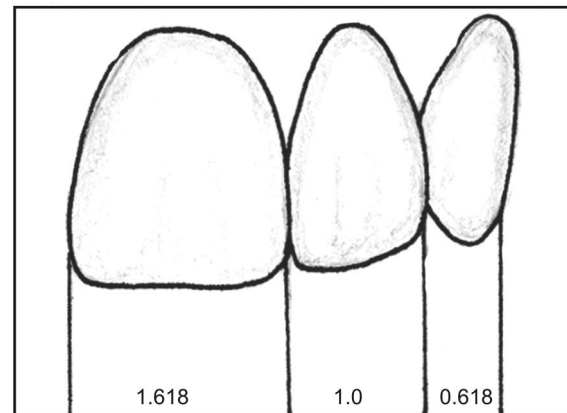
Symmetry and proportionality are very important for good esthetics which gives better smile appearance. Symmetry and proportionality are necessary for the sense of balance and harmony that are essential for optimal esthetics. Teeth symmetry can be obtained if the sizes of the contralateral teeth are same. In the anterior teeth, particularly central incisor region, incisal and gingival embrasure should be contoured carefully, the mesial half of both central incisors must be exactly equal in contour. For better esthetics, proper proportioning of anterior teeth is also necessary.

Proportionality of maxillary anteriors is governed by the concept of *Golden proportion*. According to this “if viewed directly from front, each tooth of the anterior three should be 60 of the size of the tooth immediately mesial to it” (Fig. 31.4).

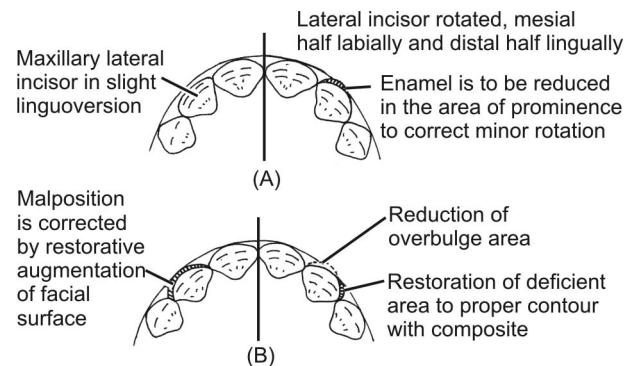
It provides better smile which is more esthetically pleasing.

### Position and Alignment

Proper position and alignment are necessary for good appearance of face and smile. Major defects in position and alignment are corrected by orthodontic treatment, but minor positional defects can be treated



**Fig. 31.4:** Teeth in golden proportion. The exact proportion of the smaller to the larger is 0.618 based on apparent sizes of teeth when viewed straight-on



**Fig. 31.5:** Correction of alignment and position with restoration and reduction in anterior teeth. (A) Before correction, (B) After correction

by composites or facial veneers (Figs 31.5 to 31.8A and B).

These type of corrections, whether composite augmentations or full veneers should not interfere with the occlusion, and also should not favour food accumulation which leads to periodontal problems.

### Surface Texture

Teeth of young persons show various surface characterizations but in the older person, teeth appear smooth and lack surface characterizations. Close examination of various anatomical structures like facets, cervical perikymata, developmental depression on the natural tooth which reflect light in many directions helps

very much to create same characters in the restored part of the tooth.

### Color

Color has the most important and very complex role in conservative dentistry. In actual, a single tooth has different shades. The gingival third has darker shade and as we go incisally, the shade becomes lighter. It means the restoration of a single tooth may require different shades in different areas.

Young persons have thick enamel, so the shade of teeth are lighter as compared to old persons, which have darker shade. In old persons, the wear of enamel takes place and the dark color of the dentin becomes dominant through thin enamel giving darker shade. A knowledge about normal tooth coloration enables a dental surgeon to create a restoration that appears natural.

Shade selection should be done before isolation of tooth. It prevents color changes due to drying and dehydration of teeth.

Color of the teeth appears different in different lights. This phenomenon is called 'metamerism'. Shade selection should be done in daylight. During shade selection, the eyes get fatigued after few seconds so eyes should be relaxed by seeing at a blue object. Its better that final shade should be checked by the patient also.

### Translucency

Translucency has a good role in esthetics and in creation of natural appearance. In natural healthy teeth, the light penetrates the enamel and goes a little bit deeper into the dentin, then it is reflected giving life-like appearance. But in case of restoration either metal, composite resin or porcelain, the light is reflected from the outer surface. Hence, esthetic appearance of vitality is compromised.

*Illusion of translucency:* Illusion of translucency produces natural look of the restoration. It is done by adding color modifiers. In cases of intrinsic yellow/brown stains, color modifiers are used for apparent translucency and to tone down bright stains, etc. Sometimes, mixture of two or more color modifiers is used to obtain desired result.

During conservative contouring and esthetic procedure, occlusal consideration is important. No attempt should be made to alter occlusion and the prepared contour should not favor food lodgment.

## CONSERVATIVE ALTERATIONS OF TOOTH CONTOURS AND CONTACTS

These are the procedures through which reshaping of natural teeth, correcting embrasures and closing of the diastema is done.

### Alteration of Shape of Natural Teeth

A. *Maxillary anterior teeth with incisal wear:* It results in closed incisal embrasure and angular sharp incisal edge.

*Treatment:* Before starting treatment, proper consultation and examination is necessary. It should be brought to the patient's knowledge that (a) what is involved, (b) the different lines of management and (c) the best in his/her case, if he/she wants to have the alterations made. In case of incisal reshaping, first area to be reshaped should be marked by a black pencil. Cutting should be done only after the patient's consent.

B. *Fractured incisal surface of maxillary central incisors:* In case where only slight incisal tips are fractured, an esthetic form can be obtained by slightly shortening and rounding incisal edges of both central incisors. After treatment, the incisors should be symmetrical and in harmony with the rest of the dentition. The patients having the habit of bruxism show attrited incisal edges. In such cases also if it is slight then conservative re-contouring is advised.

C. *Alterations of embrasures with the help of orthodontics:* This esthetic procedure is used when the permanent lateral incisors are missing and canines are drifted mesially by orthodontic means. This results in a large incisal embrasure between central incisor and canine (Fig. 31.7).

*Treatment:* Treatment of this problem includes addition of composite at the incisal slopes and esthetic contouring of canine to give lateral incisor look, which appears better from the anterior side. Total procedure consists of cleaning of teeth, selection of shade, isolation of the teeth, roughening the enamel surface, acid etching, rinsing, drying and placement of composite resins, trimming, finishing and polishing. After completion, occlusal evaluation and adjustment are necessary.



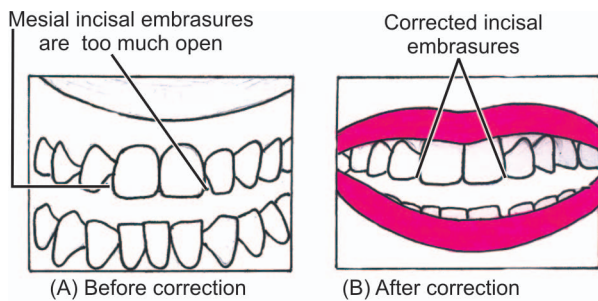


Fig. 31.6: Correction of incisal embrasures with fillings

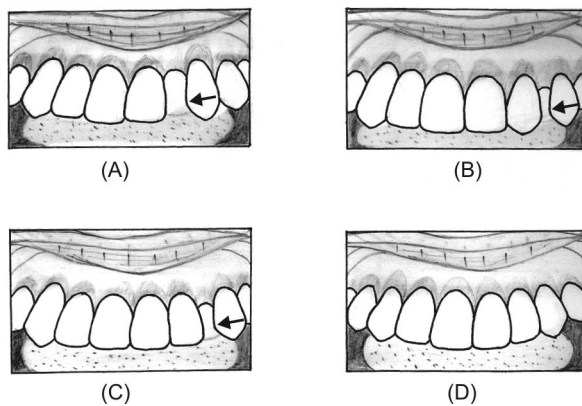


Fig. 31.7: Esthetic improvement with orthodontics and conservative help

**Mobile teeth splinting:** Mobile teeth can be splinted with light cure composite after orthodontic wire looping around them (Figs 31.8 and 31.9).

## CORRECTION OF DIASTEMA

Midline diastema sometimes poses an esthetic problem. Evaluation of etiology is of great value in treating these cases. Sometimes only removal of etiology leads to correction of diastema.

**Etiology of diastema:** Etiological factors of diastema are as follows:

1. Prominent labial frenum
2. Congenitally missing teeth
3. Small sized or malformed teeth
4. Arch size tooth size discrepancies
5. Supernumerary teeth
6. Tongue thrusting
7. Periodontal disease
8. Posterior bite collapse
9. Heredity.

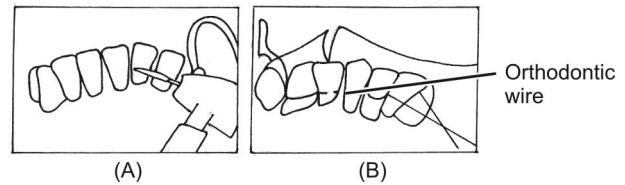


Fig. 31.8: Technique for splinting mobile mandibular incisors (A) horizontal grooves are made at the junction of cervical and middle thirds on the facial and lingual surfaces, (B) After etching of enamel in the grooves orthodontic wire is placed over which the composite resin is light cured, finished and polished

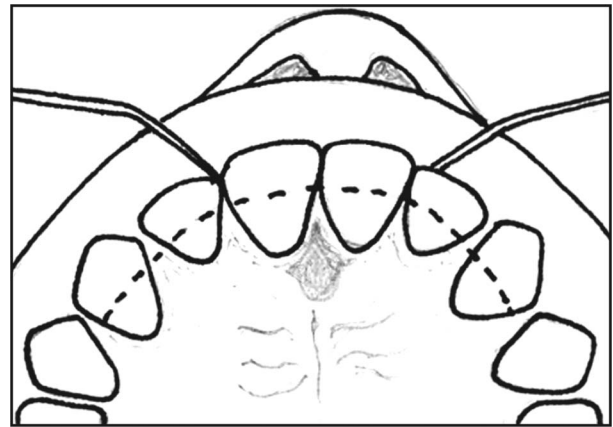


Fig. 31.9: Orthodontic wire is positioned and held in place with dental tape and bonded with composite on lingual surface to stabilize the maxillary incisors

**Treatment:** According to etiology, diastema can be closed by following operative, surgical, periodontal, orthodontic and prosthetic procedures. In operative dentistry procedure mostly composite resins are used. Before starting treatment, radiographs, study models, computer imaging are important preliminary procedures.

## Steps in Diastema Closure

The contact between the central incisors is the most important element esthetically for the dental midline. This line should be perpendicular to the incisal plane or vertical in the patient's face. It should be in the midline of the face. First of all measurement of the total space between two central incisors is done. Isolation of teeth is brought about by using cotton rolls and retraction cords into gingival crevices. Now coarse diamond bur

is used to roughen enamel surface, acid etching is performed, rinsed and dried. Apply and shape composite with the help of strip, in half of the diastema space measured previously with a caliper. Then it is cured. Finish with a finishing strip. Add and shape composite with the help of strip on another central incisor after roughening and etching it, cure it and finish with finishing strip. At last finishing bur and rubber cups with polishing paste are used for final finish of the restoration. Unwaxed floss is used to remove any excess composite material in gingival embrasures between two central incisors (Figs 31.10A and B and 31.11).

## VENEERS

Veneer can be described as a layer of tooth colored material which is applied on the tooth surface for esthetic purpose. They are used to mask the localized, generalized defects and intrinsic discoloration.



**Fig. 31.10:** (A) Diastema between maxillary central incisors (Courtesy: Dr Anil Kohli, New Delhi), (B) Diastema closed with composite (Courtesy: Dr Anil Kohli, New Delhi)



**Fig. 31.11:** (A) Maxillary incisors with diastema and right lateral incisor with cervical caries on mesial side. (Courtesy: Dr Anil Kohli, New Delhi), (B) Diastema corrected and cavity filled (Courtesy: Dr Anil Kohli, New Delhi)

### Indications for Veneers

1. Teeth having damaged, defective and malformed facial surface
2. Teeth with discolored facial surface
3. Discolored restorations.

### Types of Veneers

1. Partial veneers
  2. Full veneers
    - Full veneer with incisal overlapping
    - Full veneer with window preparation
1. *Partial veneers:* Partial veneers are used for the localized damage, defect and discoloration of the tooth, i.e. they involve only a portion of the tooth crown (Fig. 31.12).
  2. *Full veneers:* Full veneers are used when majority of facial surface or whole of the crown of a tooth is



## 316 Textbook of Operative Dentistry

discolored. Full veneers provide better esthetics as compared to the partial veneers. Before advising full veneers, thorough examination and evaluation of oral hygiene, position and alignment of teeth is essential. A veneer lacking physiological contour and having rough gingival margin leads to periodontal problems (Figs 31.12 and 31.13A and B).

Full veneers can be fabricated by two techniques:

1. Direct veneer technique
2. Indirect veneer technique.

### Direct Veneer Technique

#### Direct Partial Veneer

As described earlier, partial veneers are placed on localized discoloration. During tooth preparation or removal of defective enamel, all the stains in the pulpal direction should not be removed as it may cause injury to pulp. But the preparation in the periphery should extend to healthy enamel (Fig. 31.14).

#### Procedure

1. Plaque removal and cleaning of teeth which are to be veneered.
2. Selection of the shade
3. Isolation of the teeth with cotton roll or rubber dam
4. Removal of the defect and tooth preparation. It should be such that the preparation should extend on some sound enamel also. Removal of deep stain towards pulp is not necessary.
5. Restoration of cavity with composite resins, mostly microfilled. Application of composite is as usual i.e. first acid etching and then application.

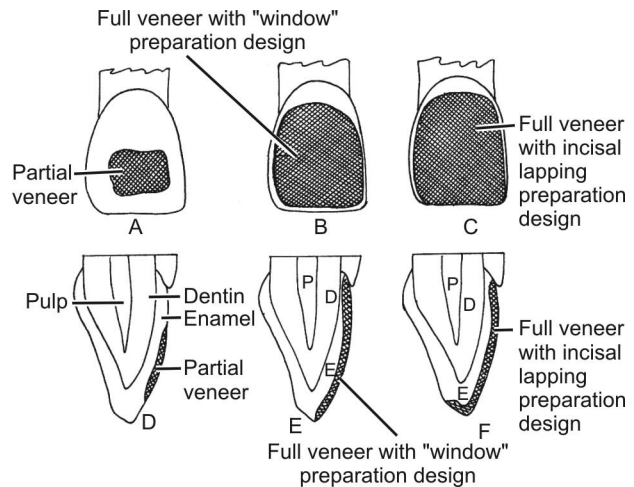
#### Direct Full Veneers

If a large part or whole of the crown is discolored, a full veneer is made. Most common indications for full veneers are the following:

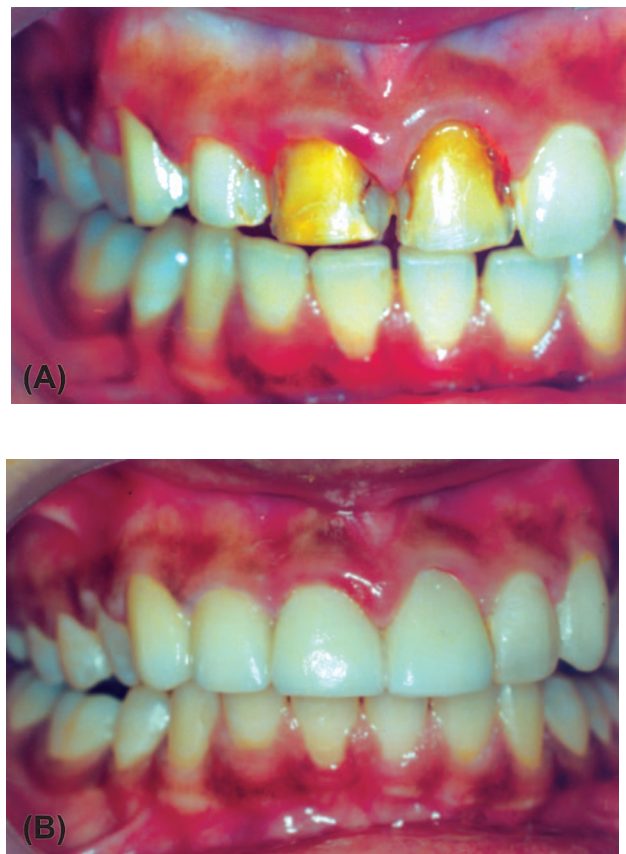
- a. Diastema
- b. Gross enamel hypoplasia of anterior teeth
- c. Grossly tetracycline stained teeth.

In most of the cases, anterior six teeth are veneered.

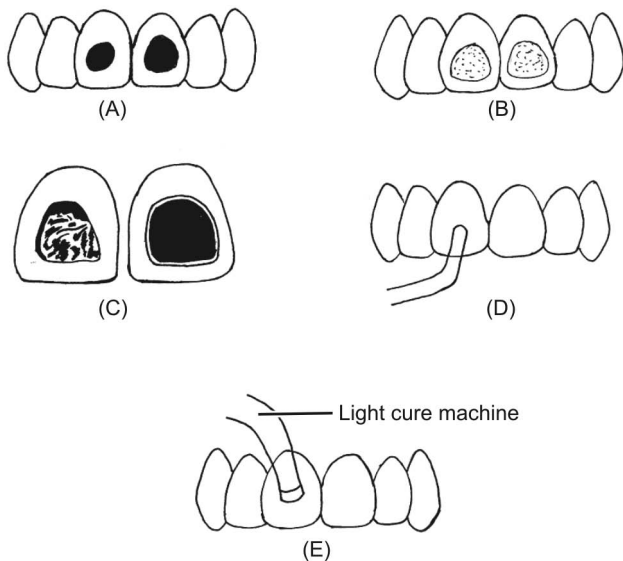
All the teeth can be veneered by direct method in one appointment, but it is very time consuming and tiring for both the patient and dentist. Hence, generally two central incisors are veneered on the first appointment



**Fig. 31.12:** Three types of veneers (A,B,C) and their respective cross-sections (D, E, F) P = Pulp, D =Dentin, E = Enamel



**Fig. 31.13:** (A) Discolored Maxillary central incisors (having fillings) prepared for veneers (Courtesy: Dr Anil Kohli, New Delhi), (B) Discolored maxillary central incisors with fillings veneered (Courtesy: Dr Anil Kohli, New Delhi)



**Fig. 31.14:** Direct partial veneer (A) Deep seated dark brown large spots of Fluorosis, (B) Dark spots removed superficially by rough diamond round bur, (C) Two central incisors seen under magnification after enamel etching. Left central incisor having deeper stain showing definite cavity walls, (D) Composite being applied, (E) Composite being light cured

and the lateral incisors and canines are veneered on the second appointment.

### Procedure

1. Cleaning of the teeth
2. Selection of the shade
3. Teeth isolation is done and gingiva is retracted with retraction cords. Reduction of tooth is done with coarse round end diamond bur. At the proximal side, the preparation should be facial to the contact point. Heavy chamfer at the gingival margin is preferable.
4. Acid etching, washing and drying.
5. Apply composite in increments. Applying in increments decreases the effects of polymerization shrinkage. When adding composites, care should be taken to create proper physiological contour, contact point, and smooth surfaces.

Tetracycline staining is also treated with veneering, though veneering of tetracycline staining is difficult. Preparations for veneers are extended subgingivally because of dark discoloration at the cervical areas. For

the shade selection, adjacent teeth are used as a guide if they have normal color. The shade at the cervical third area should be slightly darker than the rest of the crown. Canines are also slightly darker than the incisors. One tooth is completed at a time. It is better to preserve incisal enamel if it does not compromise esthetics to a large extent.

### Direct Veneering Procedure

1. Cleaning and shade selection
2. Isolation of the teeth with rubber dam
3. Tooth preparation with diamond bur. Bur should be coarse.
4. Perform the acid etching, wash and dry
5. Application of composites. Composites are placed in increment. Make one shade darker at the cervical area and the canines. Contours and contact point are checked. In one sitting central incisors are veneered and on the next sitting, lateral incisors and canines are completed (Figs 31.15 to 31.19A and B).

Tooth Preparation for full veneers, either direct or indirect, is of two types:

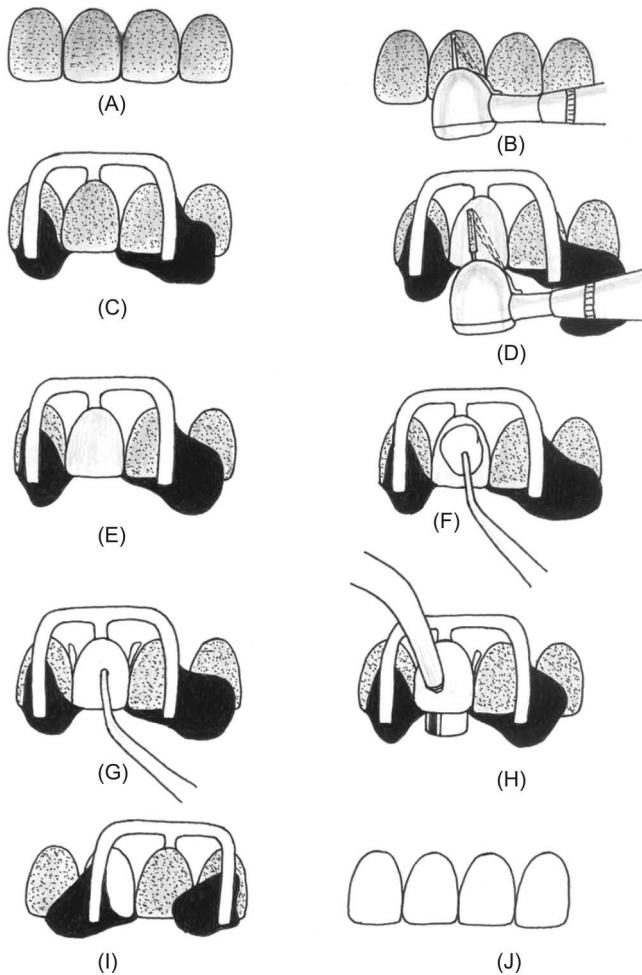
- a. Window preparation
  - b. Incisal lapping preparation
- a. *Window preparation:* Window preparation saves the functional lingual and incisal surfaces of maxillary anterior teeth. It does not extend subgingivally or involve incisal edge as shown in the figures (Fig. 31.12). Window preparation is important to decrease the chances of wear of opposing teeth.
  - b. *Incisal lapping preparation:* Incisal lapping preparation is made in cases where crown length is to be increased or when incisal defect is severe and restoration is necessary.

As tooth preparation is within the enamel, hence no temporary restoration is given before the veneer is placed. When the fabricated veneer is returned from the laboratory, thorough inspection for fracture line, chips, air bubble and roughness is done. Veneer should be placed only on clean dry teeth to avoid any contamination (Fig. 31.12).

### Indirect Veneer Technique

Direct veneer technique is much time consuming and tiring for both the patient and dentist. Patient may become uncomfortable and restless during long appointment. On the other hand, veneers formed by

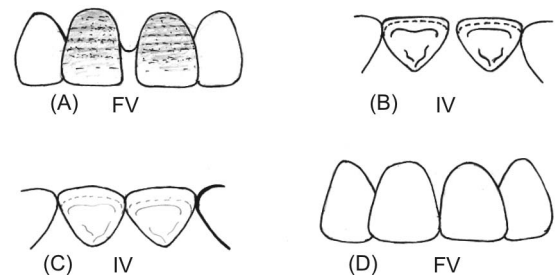




**Fig. 31.15:** Direct full veneers for discolored teeth using light-cured composite

- (A) Hypoplastic discolored enamel
- (B) The clinical crown area is inscribed by cutting a shallow groove with a very small (no. ¼) round bur under coolant spray.
- (C) Tooth isolated with rubber dam and no. 212 cervical clamp.
- (D) Enamel surface is abraded with rough diamond bur.
- (E) Enamel surface is etched
- (F) Resin opaquing material is applied and light cured.
- (G) Light cured composite of the required shade is added in thin layers and properly shaped.
- (H) Composite is light cured
- (I) Adjacent tooth is isolated for veneering.
- (J) One by one veneering of all discolored teeth is completed, finished and polished

the indirect technique have superior strength and esthetics.



**Fig. 31.16:** Direct Full Veneers with diastema closure using light-cured composite (A) Discolored eroded central incisors with hypoplasia and diastema (FV), (B) Etched incisal lapping preparations of facial surface of central incisors for direct full veneer. Preparation is extended onto mesial surface to provide for closure of diastema (IV), (C) Direct full veneers remove diastema and restore proximal contact (IV), (D) Veneers completed on maxillary central incisors (FV), FV = Facial view IV = Incisal view

Chair time required for indirect veneer is very less as compared to direct veneer because most of the work is done in the laboratory. Indirect veneer technique requires two less time consuming appointments. Indirect veneers are made thick, so more tooth reduction is required. Removal of 0.5 to 1 mm of enamel is done. Indirect veneers are better for proper contour, contacts and shade (Figs 31.18 and 31.19).

Indirect veneers are of the following types:

- a. Processed composite veneers
  - b. Etched porcelain veneers
  - c. Castable ceramic veneers.
- A. *Processed composite veneers:* Processed veneers are made for superior physical and mechanical properties. As compositions of both direct and indirect veneers are similar, so indirect veneers can be bonded to the teeth with a tooth bonding agent. It is brought about by a chemical bond between the bonding agent and bonding medium. If tooth preparation is done with coarse diamond instrument and is properly etched, then it provides very good retention. Processed composite veneers are easy to finish and polish and also can be easily repaired. Processed veneers are made in the cases which show attrition of anterior teeth due to occlusal stress. As has been stated earlier, both window preparation and incisal lapping design are made according to need.



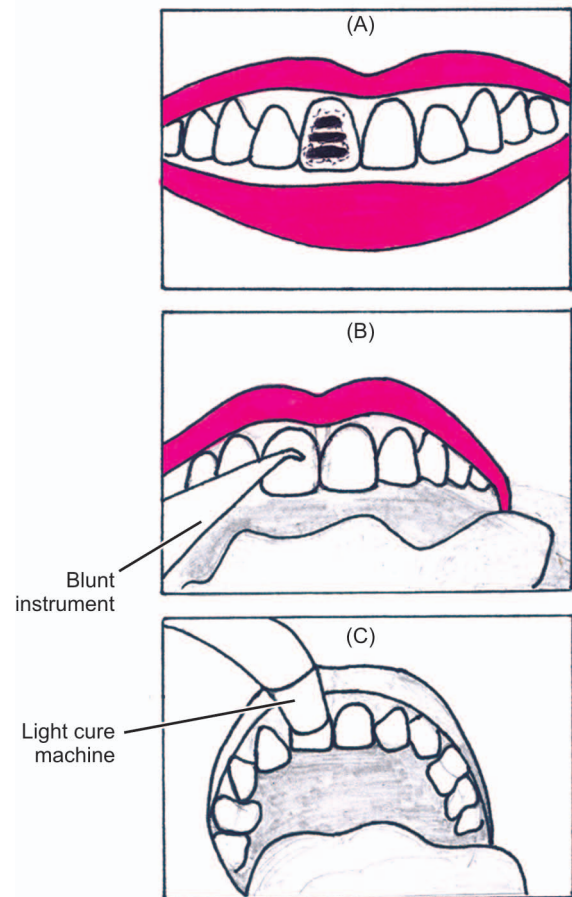
**Fig. 31.17:** (A) Defective veneer on left upper central incisor (Courtesy: Dr Anil Kohli, New Delhi), (B) Defective veneer changed with new veneer (Courtesy: Dr Anil Kohli, New Delhi)

Processed composite veneers are placed by the following sequence of steps:

- a. Acid etching
- b. Application of bonding agents to the tooth enamel.
- c. Placement of veneer by using fluid resin bonding medium. After placement, it can be easily finished and polished (Figs 31.18 and 31.19A and B).

### Etched Porcelain Veneers

Etched porcelain veneers are commonly used indirect veneers. In these porcelain veneers, internal surface is acid etched. Now acid etched surfaces of tooth enamel form a stronger bond as compared to unetched.

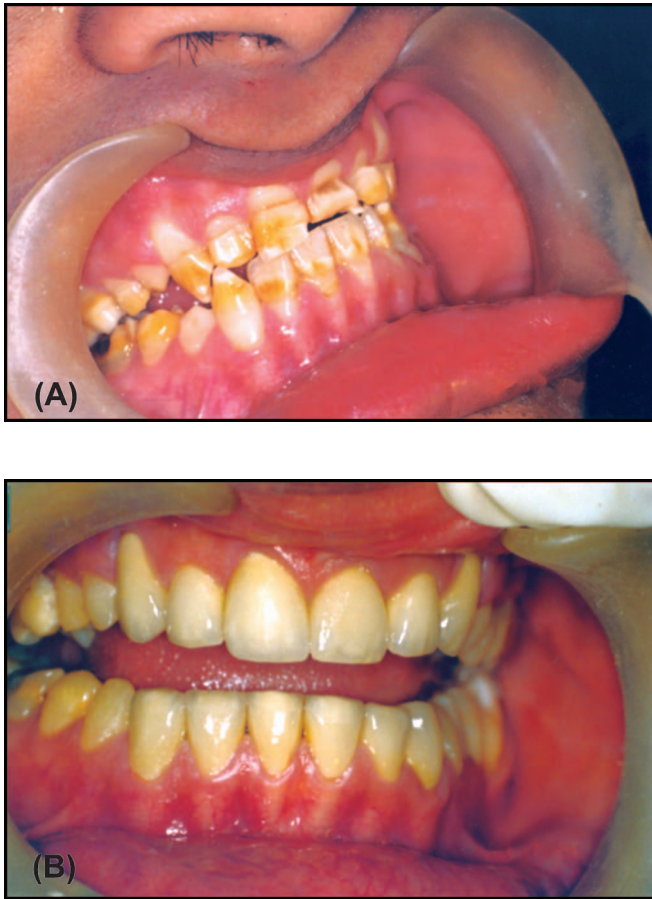


**Fig. 31.18:** Replacement of defective direct composite veneer by indirect processed composite veneer (A) Right central incisor with defective direct composite veneer, (B) On right central incisor veneer is positioned and seated, (C) Veneer bonding medium is being light cured

### Advantages of Etched Porcelain Veneers

1. Better retention on tooth surfaces due to stronger bond
2. Less prone to stains
3. Good esthetics
4. Compatible with periodontal tissues
5. Less prone to fractures than other types of veneers

After cleaning and shade selection, the isolation of teeth is done and then tooth surfaces are prepared with round end diamond bur. Preparation should be incisal lapping veneer type. After completion of the preparation, an impression is taken in rubber base



**Fig. 31.19:** (A) Grossly hypoplastic and discolored maxillary and mandibular anterior teeth (Courtesy: Dr Anil Kohli, New Delhi), (B) After veneering of maxillary and mandibular anterior teeth (Courtesy: Dr Anil Kohli, New Delhi)

impression material and sent to laboratory for veneer formation. When crown is received from the laboratory first of all check for any over-extended margins, roughness, cracks, internal etching. These defects are either corrected or sent to the laboratory for correction, if it is not possible in the clinic.

A completely finished veneer should be seated on clean, dry and isolated prepared tooth. Internal surfaces of porcelain veneers are conditioned with silane primer which is a coupling agent (i.e. it makes bond between porcelain and resin). Most of the retention in porcelain veneers is obtained from etched porcelain surface itself. After setting, excess cured resin is carefully removed by BP knife. Sometimes, porcelain margins are over extended or rough, then recontouring and trimming is

required for esthetics and gingival health, which is done with fine diamond bur.

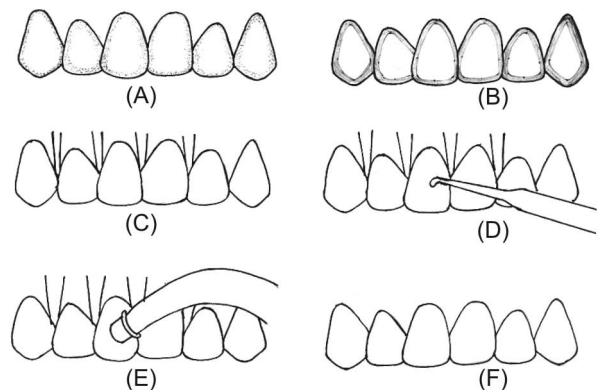
Etched porcelain can be used on the anterior teeth that are malformed due to either developmental or any other reason. Etched porcelain veneers can be given in darkly discolored teeth, but here they do not give excellent result, but condition can be improved to a large extent (Figs 31.20 to 31.22).

### Castable Ceramic Veneers

Commonly used castable ceramic is 'DICOR'. Castable ceramic veneers are fabricated for only light to moderate discolorations because it is very translucent material. Castable ceramic veneers are formed by lost wax technique. Preparation of tooth and bonding are just like etched porcelain veneers. Castable ceramic veneers are not finished with rotary instruments as rotatory instruments cause loss of surface coloration. In most of the cases, little marginal finish is required due to good marginal fit of the castable ceramic veneers.

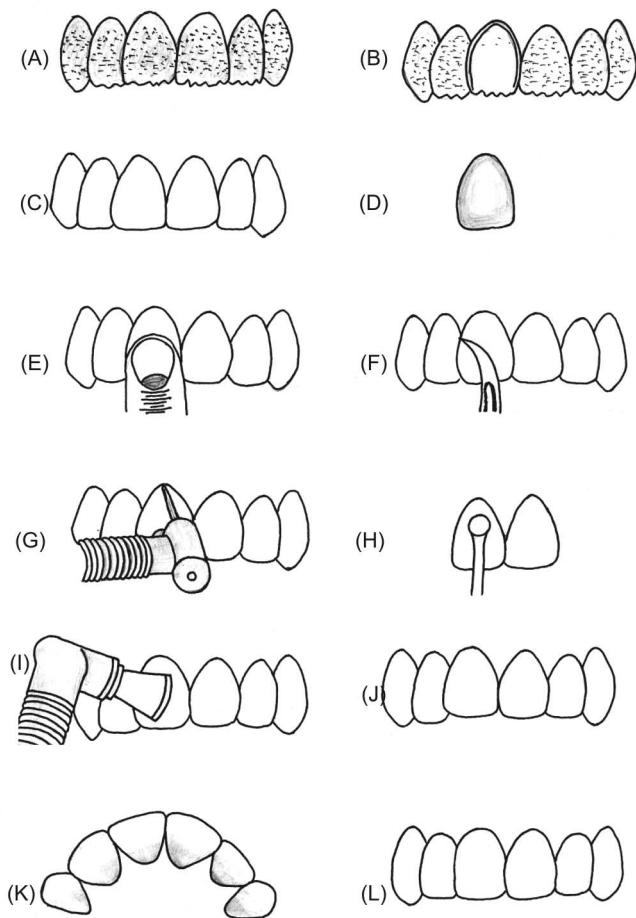
### VENEER FOR METAL RESTORATION

Sometimes, veneers are placed on the facial surface of tooth which has been restored with metal (Figs 31.23A and B). A metal restoration which has to be veneered is examined properly and radiograph is taken to reveal



**Fig. 31.20:** Indirect processed composite veneers. (A) In maxillary anterior six defective direct composite veneers, (B) For indirect-processed composite veneers finished window preparations, (C) Right central incisor isolated, etched and ready for veneer bonding, (D) Veneer bonding medium is applied and veneer is positioned with blunt instrument, (E) Veneer-bonding medium is light-cured and gradually all six veneers are bonded on all six teeth, (F) Completed indirect-composite veneers on all six teeth

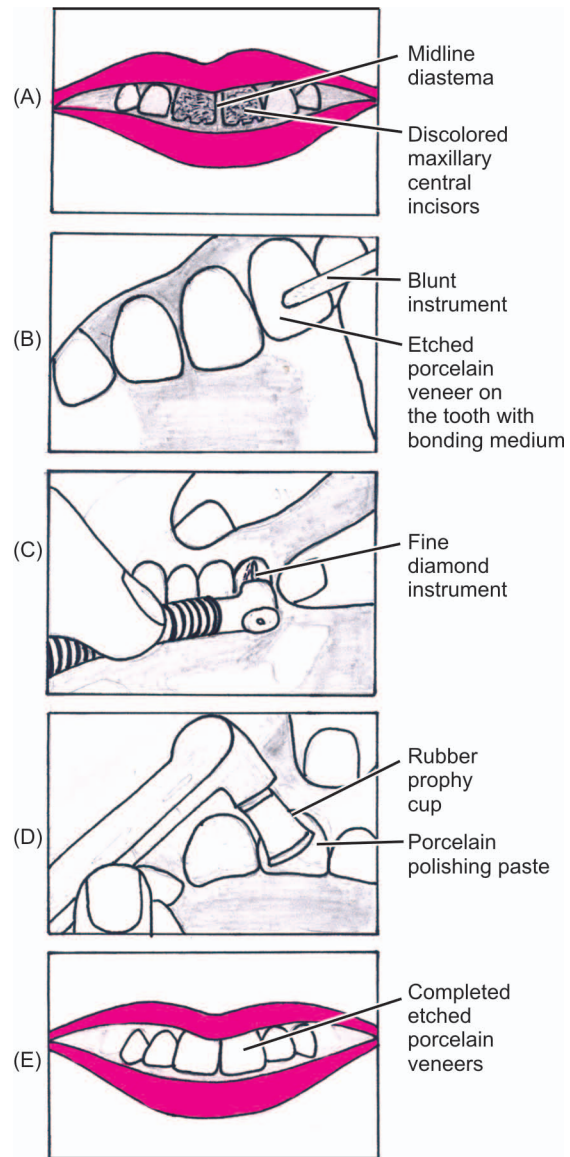




**Fig. 31.21:** Indirect etched porcelain veneers with incisal overlapping (A) Generalized discoloration of upper six anterior teeth along with facial and incisal hypoplastic defects, (B) Hemipreparation to assess and guide tooth preparation, (C) Incisal lapping veneer preparations completed, (D) Thin layer of bonding medium is placed in the etched porcelain veneer on the fitting surface, (E) The veneer is carefully seated on the tooth, (F) The marginal excess is removed by a no. 12 surgical blade in a no. 3 B.P handle, (G) Rough gingival margins are finished with fine diamond bur, (H) Lingual areas are finished with a big round shaped diamond bur, (I) Porcelain polishing paste is used for final polishing and luster, (J) In this way all upper six anterior teeth are veneered, (K) Lingual view of the veneered crowns of teeth, (L) Etched porcelain veneers 24 months later

any defect. Veneer for metal restoration is made in the following steps:

1. Cleaning of the teeth
2. Shade selection



**Fig. 31.22:** Procedure for indirectly etched porcelain veneers. (A) Generalized discoloration of maxillary central incisor along with facial and incisal hypoplastic defects and midline diastema, (B) The (prepared or readymade) etched porcelain veneer is placed with bonding medium on the tooth carefully and lightly jiggled to place with a blunt instrument, (C) Rough gingival margins are finished with a fine diamond instrument, (D) Final surface lustre is imparted through the use of porcelain polishing paste applied with a rubber prophy cup, (E) Completed etched porcelain veneers

3. Isolation of the area with cotton roll or rubber dam and the gingiva is retracted by gingival cord, if restoration is subgingival.



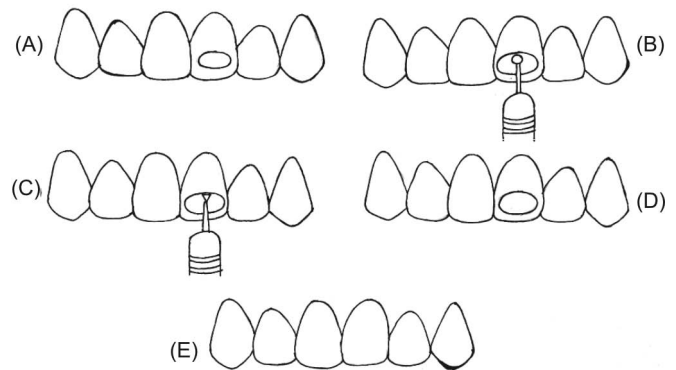


**Fig. 31.23:** (A) Fractured and decayed anterior teeth (Courtesy: Dr Anil Kohli, New Delhi), (B) After crowning and veneering (Courtesy: Dr Anil Kohli, New Delhi)

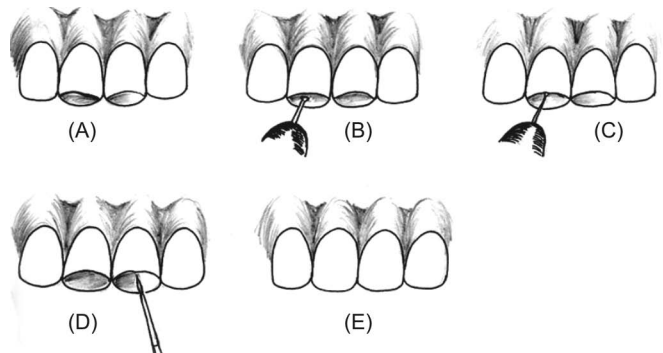
4. Preparation includes removal of the metal and enamel. Butt joints are made at the cavosurface margin. Preparation is done in the facial surface, and in the proximal surface just facial to contact point. Preparation should not extend on the occlusal surface. Retention of the restoration is increased by forming grooves along the gingivoaxial and linguoaxial angles. Enamel surface is beveled to improve esthetics.
5. Acid etching of the cavity and then drying is done.
6. Placement of composite as usual i.e. first application of primer, curing and then composite paste, and then curing.
7. Creating the natural contours with the composites.
8. Finishing of the restoration.

### Repair of Veneers

With the passage of time, failure of veneers occurs due to wear, discoloration or accidental breakage.



**Fig. 31.24:** Repairing veneer (A) Damaged veneer on maxillary left central incisor, (B) Preparation with round diamond instrument, (C) Undercuts placed in existing veneer with a No. ¼ inverted cone bur, (D) Completed preparation is shown isolated and etched, (E) Veneer restored to original color and contour with light cured composite



**Fig. 31.25:** Repair of worn out incisal edges of veneers on central incisors (A) Worn out incisal edges of veneers on central incisors, (B) Incisal edges cleaned with inverted cone No. 1 bur, (C) With No. ¼ inverted cone bur undercuts are placed at margins of existing veneer, (D) Etching of the preparation, (E) Veneer repaired with composite to original shade and contour

Repair of veneers may be of two types:

1. Veneers on tooth surface
2. Veneers on the metal restoration.

Repair of veneer on tooth surface: On tooth surface repair of veneers are of two types:

- A. *Repair of direct composite veneers:* These veneers should be repaired with the same material by which they have been prepared after cleaning and preparation of retentive grooves and roughening the surface with coarse, round bur. Composite is applied after acid etching and drying the area. (Figs 31.24 and 31.25).

B. *Repair of indirect processed veneers:* Indirect processed veneers are made up of the following:

- i. *Composite:* These are repaired like direct composite veneers.
- ii. *Porcelain:* Repair of porcelain veneers includes acid etching with 10% Hydrofluoric acid (HF), isolation of the tooth or teeth to be veneered with rubber dam. A chalky-white appearance indicates good etching of the surface. Application of coupling agent after rinsing and drying. Application of resin bonding agent, placement of chair-side composite, curing and then finishing is done.

### Repair of Veneer on Metal Restoration

Repair of veneer on metal restoration can be done in the following steps. Cleaning of the tooth, shade selection, isolation of the area, preparation of the facial surface by removing the remaining material, and creating chamfer finish line. In the metal along the line angles, retentive grooves are made.

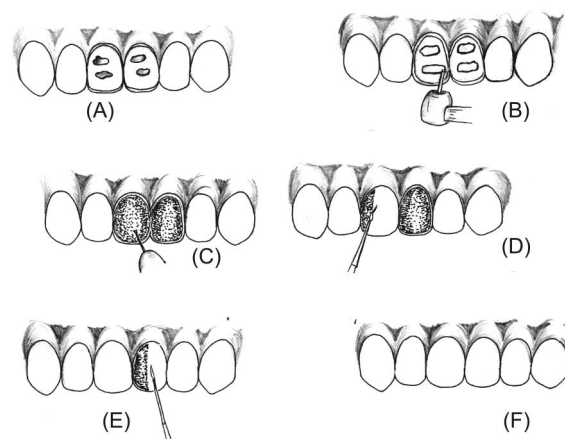
Application of acid on the metal surface, rinsing and drying is done. Acid is used to clean the metal surface and not for etching. Polyester strips and wedges are placed interproximally to obtain proper contours. Application of opaquing resin with a brush on the metal surface is done. An adhesive resin liner containing 4-META is also used. It bonds to metal and provides additional retention and masking of the metal color. Placement and curing of composite material first on the cervical area is done in small increments of the material. Application of shade selected composite resin is done in small amounts and curing is done till the desired contour and esthetic is obtained (Fig. 31.26).

### ACID ETCHED RESIN-BONDED SPLINTS

There are many situations when pathological tooth mobility occurs, and if it is not removed early, then it may cause loss of tooth. During splint formation, it is important that the splint should be hygienic, i.e. it should not favor food lodgment and should not hinder in oral hygiene, occlusion and functions.

### PERIODONTALLY INVOLVED TEETH

Teeth which are loose or teeth undergoing periodontal procedure require splinting which remains even continued after the procedure.



**Fig. 31.26:** Repair of wornout veneers in metal restorations with light cured composite veneers. (A) Labial surface worn out veneers, (B) Worn out veneers are removed and metal surface is exposed (C) Mechanical retention is placed in metal with ¼ No. inverted cone carbide bur, (D) Masking agent (opaquing resin) is applied to cover the metal surface, (E) Composite resin is applied and cured, (F) Second layer of composite resin is applied, and cured and veneers finished and polished

Teeth that are to be splinted are cleaned and polished with pumice. Isolation of the area is done by cotton rolls, retraction cords and rubber dam. Now the proximal surfaces of the teeth to be splinted are reduced with coarse, flame-shaped diamond bur to create approximately 1 (one) mm of space between the teeth. In areas where enamel is not present; for example, root surface, a root bonding is applied before composite placement and mechanical interlocking is also performed to enhance retention. Other procedures like acid etching, rinsing and drying are done as usual.

Sometimes, orthodontic wire is also used before light cure for better strength. Orthodontic wire may be applied straight or wrapped and twisted in figure-eight manner (Figs 31.8 and 31.9).

### Teeth Stabilization After Orthodontic Treatment

After aligning of teeth by orthodontic treatment, their retention is necessary to prevent relapse. Full mouth impressions are taken to make casts, and wire is adopted on the lingual surface of the teeth to be splinted with three firm teeth on either side such that it is not hindering in occlusion. The enamel etching and rinsing and drying on the lingual surface is done. The wire is

## 324 Textbook of Operative Dentistry

fixed on the teeth in the mouth on the lingual surface with light cure composite resins as usual.

It is important not to extend composites in the interproximal areas. After curing of material once again occlusion is checked. This splint serves to stabilize the teeth in the correct position. It is held in position for about six months or more for permanent stabilization of the teeth.

### Correction of the Rotated or Evulsed or Partially Avulsed Teeth

Sometimes natural teeth are rotated. Such rotated natural teeth or accidentally evulsed teeth can be corrected and splinted. During road-side accidents,

games or fight involving facial injuries, tooth evulsion along with soft tissue and hard tissue damage is common. The most common teeth which get evulsed are maxillary central incisors. Evulsed teeth should be replaced as soon as possible and in the mean time, they should be placed in the saliva, milk or wet towel.

Tooth are cleaned and washed in normal saline, (if not available then in tap water) and replaced in the socket quickly. An orthodontic wire is adapted on the facial surfaces of the evulsed tooth and adjoining one-one or two-two teeth. Teeth surfaces are acid etched, rinsed and dried carefully. Now light cure is placed to the facial surface of the repositioned teeth and adjoining teeth. Composite should not extend in the proximal surfaces.



**Fig. 31.27:** (A) Upper central incisors with tooth powder abrasion on the incisal middle half of labial surface (Courtesy: Dr Anil Kohli, New Delhi), (B) Abrasion on upper central incisors repaired with light cured composite (Courtesy: Dr Anil Kohli, New Delhi)



**Fig. 31.28:** (A) Fractured maxillary left central and right lateral incisors (Courtesy: Dr Anil Kohli, New Delhi), (B) Fractured teeth repaired with readymade post and core and light cured composite in one sitting (Courtesy: Dr. Anil Kohli, New Delhi)



in one sitting (Figs 31.28 A and B and 31.29 A and B).



**Fig. 31.29:** Incisal edge repair (A) Incisal edge of right maxillary lateral incisor fractured, (B) Fractured incisal edge repaired with light cured composite

Splint is removed after 4 to 8 weeks if the tooth is asymptomatic and the pulpal test is normal. Refer chapters 25 and 30 of the Textbook of Endodontics with MCQs by the authors for details.

## DEFECT AND DAMAGE REPAIR

- A. *Abrasion repair:* Abrasion can be repaired by composites after etching the enamel and dentin (if dentin is also involved). Upper central incisors are more often abraded by rough tooth powder. (Fig. 31.27A) Abrasions are satisfactorily repaired with composites (Fig. 31.27 B).
- B. *Fractures crown repair:* Fractured crowns of the anterior teeth can be repaired with composite resin

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## 326 *Textbook of Operative Dentistry*

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Currently various types of dental restorative materials are available. Direct gold is pure 24- Karat gold that can be compacted directly into the prepared cavities. Gold restorations are used to restore class I, II, III, V and class VI cavities and to repair holes in crowns. Direct gold is also used to repair abraded cusps. If proper home care and proper restorative techniques are employed, direct gold restoration lasts for a lifetime, because of superb biocompatibility of gold with the oral environment and its excellent marginal integrity. Goel and Chandra et al reported gold foil as the best material for apical sealing before replantation when improvement in biting force was used as the criterion.

#### **Properties of Direct Gold**

1. Brinell hardness number (BHN) is 25, which rises to 75 during condensation.
2. Tensile strength is 19,000 psi which rises to 32,000 psi.
3. Yield strength is 0 which increases upto 30,000 psi.
4. Density of pure gold is 19.3, while that of compacted gold is 16.5 gm per cubic centimeter.

The exact mechanism of how the properties of pure gold are enhanced is not completely understood.

#### **Indications for the Use of Direct Gold**

1. For invisible small carious lesions.
2. For small erosions on all the surfaces of premolars, canines and incisors where esthetics is not important.
3. For hypoplastic or other defects on the facial, incisal or lingual areas requiring restoration.
4. For limited extension and small cavities.

The order in which direct filling gold is commonly used is as follows:

- a. Class I cavities of all teeth
- b. Class V cavities of all teeth
- c. Class III cavities of all teeth
- d. Class II cavities of limited number of bicusps and on mesial surface of molars
- e. Class VI cavities.

#### **Contraindications for the Use of Direct Filling Gold**

Direct gold fillings are contraindicated in the following conditions:

1. If manipulation is difficult because of limited accessibility.
2. If large amount of tooth is destroyed and pulpotomized and root canal treated teeth.
3. If patient is uncooperative, very old or handicapped
4. If esthetics is of prime importance.
5. Large pulp chambers or periodontally weak teeth.
6. Expected functional period of the tooth is not more than 2 years.

#### **Advantages of Direct Filling Gold**

1. Noble metal does not tarnish and corrode.
2. It provides permanent restoration.
3. No cementing medium is required.
4. Coefficient of thermal expansion near to the dentin.
5. Malleability provides permanent self sealing margins, hence leaky margins is never a problem.
6. Can withstand compressive forces even in thin layers hence deeper cavity preparation is not required.
7. Polished surface is plaque repulsive.
8. If proper gold restoration is done it can last as long as the tooth.
9. It does not cause tooth discoloration because of good adaptation to the cavity margins and walls.
10. The direct gold restoration is insoluble in oral fluids.
11. The polish and smoothness last indefinitely when compared with other restorative materials.
12. There is a good response of the adjacent gingival tissues to the gold restoration.
13. Direct gold restoration can be completed in one appointment.

### Disadvantages of Direct Filling Gold

1. Highly technique sensitive.
2. Unesthetic.
3. Indicated only in small cavities.
4. Remaining tooth structure should be strong as condensation forces are very heavy.
5. High thermal conductivity can be a problem in a newly restored tooth.
6. The manipulation of gold is difficult and time consuming.
7. Expensive.

### Types of Direct Gold

Direct-filling gold is of several types. All of the gold materials are compatible against cavity walls. Manipulation procedures for various types vary and are used according to the situations.

The forms and the types of direct gold are as follows:

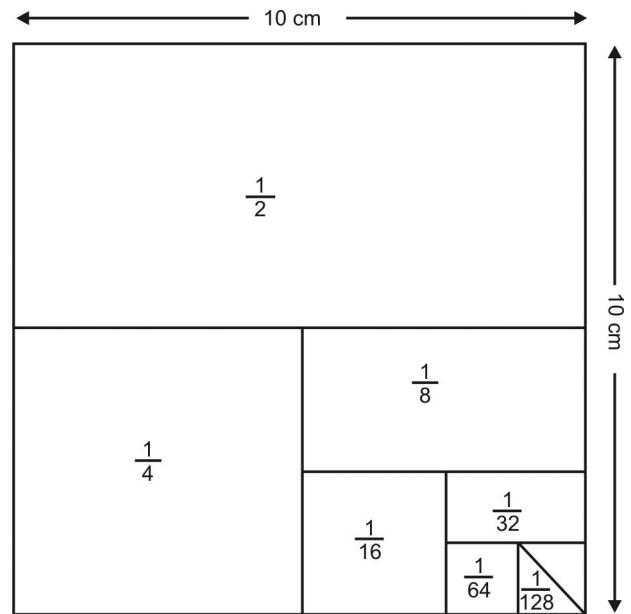
1. Gold foil
2. Platinized gold foil
3. Crystalline gold or electrolytic precipitated (a) mat gold (b) mat foil (c) electraloy
4. Powdered gold.
1. *Gold foil*: This is the oldest form of direct filling gold. The gold foil is made by beating pure gold into thin sheets. The size of the sheets is 10 × 10 cm (4 × 4 inch). The foils are supplied in books which are separated by thin paper pages, in each book there are twelve gold foils. The thickness of gold foil is 1.5 micron.

The size of 10 × 10 cm foil is too large for use in restoration. So before insertion of the foil into the cavity, it is cut, rolled into ropes, cylinders or pellet.

The pellet size may vary as they are rolled from  $\frac{1}{2}$  to  $\frac{1}{128}$  sections cut from a sheet of foil. The rolled pellets can be stored in a gold foil box. To prevent the formation of oxide layer on the pellets, cotton dipped in 18 percent ammonia is placed in the gold foil box (Fig. 32.1).

The advantage with custom-made pellets is that different size and shaped pellets which are more cohesive and require less gold can be made.

2. *Platinized gold foil*: The foil is made up by sandwiching a sheet of platinum between two sheets of gold foil No. 4. After placing the sheets, the mass is hammered until a final sheet of No. 4 foil is obtained.



**Fig. 32.1:** Template for pellet size of gold foil. Gold foil sheet is cut according to the required pellet size

The platinum content in foil is 15 percent. The platinum increases the hardness of the restoration, hence it is used in areas of high occlusal stress like cusp tips and incisal edge of anterior teeth.

3. *Mat gold*: It is a pure, crystalline precipitated gold deposit prepared by an electrolytic process. Pure gold is sintered in an oven, which helps to hold the crystalline gold together. After this, gold is heated slightly below the melting point so that partial fusion occurs. The resultant material is a spongy structure of loosely aligned crystals, which adapt well to the cavity walls. Mat gold is used to form the core of restoration and its cohesive quality shortens the placement time.
4. *Mat foil*: In this, mat gold is sandwiched between the two cohesive gold sheets. The advantage of mat foil is that the gold sheets hold the crystalline gold together when it is placed and condensed into the cavity. Nowadays it is not used as it is difficult to condense.
5. *Electraloy*: It is the recent type of direct filling gold. It is produced by electrolytic precipitation method. In this, mat gold is alloyed with 0.1 to 0.5 percent by weight with calcium. Then this crystalline structure is sandwiched between two gold foils like mat gold. Calcium is added to increase the hardness and

strength. This direct filling alloy on condensation produces the hardest direct filling gold surface.

6. *Powdered gold or gold dent:* It is a combination of atomised and chemically precipitated gold powder embedded in a wax-like organic matrix. The average particle size is of 15 microns. The atomized particles with organic matrix are wrapped in No. 2 or No. 3 foil. Each pellet contains about 10 times more gold than a gold foil pellet. Before condensation matrix is burned away so that only pure gold is left. Powdered gold does not require very sharp line angles and point angles in cavity similar to composites.

### Cohesion

The gold is inserted into the cavity under pressure so that during welding, minimal porosity or internal void spaces are there. Due to metallic bonding, the pure clean surfaces of the gold cohere together and thus welding occurs. For successful welding, the gold must be in a cohesive state. Surface impurities present on the gold prevent cohering and the gold is said to be non-cohesive. Gases are attracted by pure gold which makes it non-cohesive. These gases must be removed from the surface of gold by a process called *degassing* or *annealing* before gold is compressed into cavity.

### Degassing or Annealing

Degassing is a better term because in annealing, along with the removal of surface contamination, internal stress relief or recrystallization also takes place but here only surface contamination is to be removed. Degassing is specially required for non-cohesive gold, in which an ammonia layer is placed as a protective coating over the foil by the manufacturer, to prevent other gases and their oxides from contaminating the gold and to prevent clumping of pellets.

Degassing methods can be grouped into bulk and piece. In bulk method, many gold pellets are heated together. The pellets are placed on the mica tray and then heated over open gas or alcohol flame. The tray is heated until the gold pellets achieve the temperature above 400°F. In electric annealer, the gold is heated for 10 minutes at 850°F and then it is cooled for placing in the cavity. The disadvantages of bulk method are as follows.

1. Unused gold may be left and it can be wasted due to contamination.
2. There is a danger of over heating. Over heating may melt the metal or may make it brittle.
3. It is difficult to select the annealed gold piece that will fit into the cavity.

In piece method, the gold foil is held in carrier and heated over clean blue flame of absolute or 90 percent ethyl alcohol. The flame temperature is about 1,300°F. The gold is heated until the metal becomes dull red. Under-heating should be avoided because the cohesive properties are impaired and pitting of the restoration may also occur.

### Compaction

The aim of compaction is to achieve the following goals:

- a. Weld the pieces of gold together
- b. Adapt the gold to the margins of the cavity
- c. Remove the air entrapped in between the gold pieces
- d. Harden the mass by cold working
- e. Strengthen the restoration.

### Types of Condensers

Compaction is done either by hand pressure, hand mallet, automatic mallet, pneumatic mallet, or electro-mallet. In hand condensation, gold is forced into the cavity in a proper direction by condenser. In hand mallet method the operator places the condenser in the position while the assistant taps with the mallet which weighs about 50 grams. In automatic mallet pre-determined force is applied as the force is controlled by a spring fitted inside the mallet. As soon as the desired force is achieved the spring is released.

In pneumatic condenser (mechanical condenser), the no. of compaction strokes are controlled by a rheostat attached to an electric motor, while condensation pressure is regulated by a knob present on the back of hand piece. Gold condenser consists of a nib or working tip and a shank of about 2.5 cm as in case of pneumatic condensers which fits in the malleting hand piece. In hand mallet condenser, the end of the shank is blunt to receive blows from the mallet and it is about 15 cm long.

Condenser nibs are of different size and shapes. They may be round measuring 0.4 to 0.55 mm in



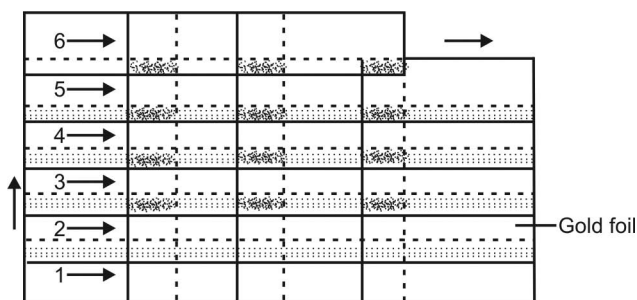
### 330 Textbook of Operative Dentistry

diameter, rectangular measuring  $1 \times 1.3$  mm or parallelogram-shaped measuring  $0.5 \times 1$  mm. In all the nib faces there are pyramidal serrations to prevent slipping on the gold. The shank of the condenser may be straight, monangled or offset. Under the constant malleting force if the nib area is small, greater pressure is applied per square cm, because area of a circle is directly proportional to the square of the diameter. If the diameter of the nib is reduced to half, the compaction force per square cm is increased to four times.

The principles involved in compaction of gold are as follows:

1. Weld the gold to make a cohesive mass.
2. Wedge maximum gold into the cavity with minimal air inclusion.

By careful compacting methods due to coherence, welding between the noble metal takes place. In spite of careful compaction, some void spaces (bridging) occurs in the compacted gold and along the cavity walls. For successful restoration, the void number must be minimum. When the gold foil is compacted, linear channels of microporosity occur but due to welding of the foils, the microporosity channels are not confluent with each other. Due to microporosity, the gold restorations are veneered with gold foil. For compaction a stepping pattern is used (Fig. 32.2).

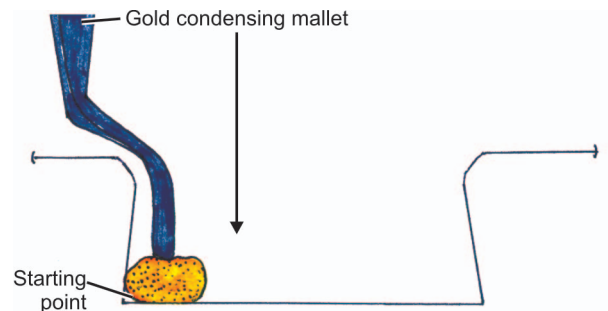


**Fig. 32.2:** Stepping pattern of one-third overlap of direct filling gold. Condenser moved across the surface of gold in an order of stepping motion. Condensation begins at position 1 and moves to the right after position 2 is moved to the right with overlapping. A part of 1 then continues in rows of 3,4,5 and 6. Layer of dark dotted line is more condensed than light dotted line

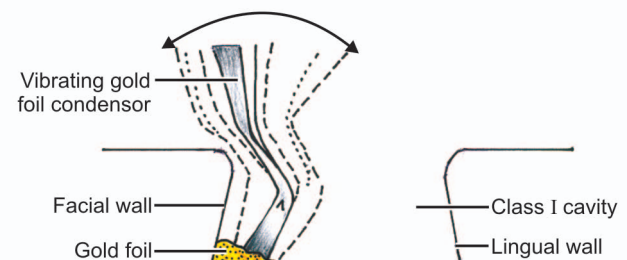
#### Compaction Technique

A gold piece is placed in the starting point which is usually in the corner of the cavity. By a condenser

malleting is done in the center of the mass. The angle between the face of the condenser and the gold should be between 6 and 12 degrees. Condensation is done with rocking motion of the instrument from the plane, perpendicular to the plane of the wall. During condensation, as the condenser is moved towards periphery, each succeeding step of the condenser should overlap the half of the previous step. Some compaction also occurs due to lateral movement of the gold against surrounding cavity walls (Figs 32.3 to 32.6).



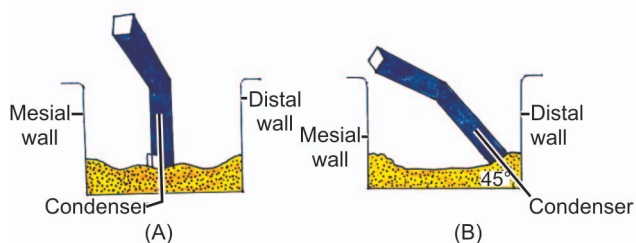
**Fig. 32.3:** First gold pellet being condensed in the starting point angle



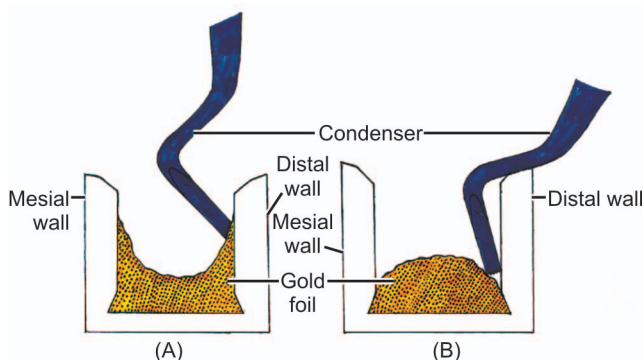
**Fig. 32.4:** Vibrating motion of the condenser is used to condense the gold foil

#### Finishing

The first step in finishing of the gold restoration is burnishing. A specially designed Spratley burnisher is pressed with pressure over the metal to close the voids. During burnishing, gold overlaps the edge of the cavity making it difficult to detect the end of the cavity. By Morse scaler and Jones knife, the restoration is contoured and the excess is removed from the margins. Smoothing of the restoration is done by disks with light pressure. The fine garnet disks and cuttle disks are moved from the metal to the tooth. Lubricants and air coolants may be used to prevent the temperature elevation in the restoration.



**Fig. 32.5:** Condensation of direct gold (A) Condensation against pulpal wall by holding condenser at 90 degrees to the pulpal floor, (B) Condensation at the point angle is done by holding condenser at 45 degrees angle, in such a way that it bisects the line angle and trisects the point angle. Condenser is moved from the center towards the periphery



**Fig. 32.6:** Direct filling gold restoration (A) Direct gold filling well adapted to cavity walls, (B) Incorrect adaptation of direct gold filling. Condenser failed to adapt the gold to cavity walls

For polishing, in smooth rubber cup, silica, pumice, metallic oxide compounds or Amalgross is taken and used for smoothening the gold restoration. If finishing of the restoration is properly done, luster will be seen after polishing. Finished or polished restorations do not tarnish or corrode in oral fluids. They also promote the health of the gingival tissue which is in contact with the restoration.

## PRINCIPLES OF TOOTH PREPARATION FOR DIRECT GOLD RESTORATIONS

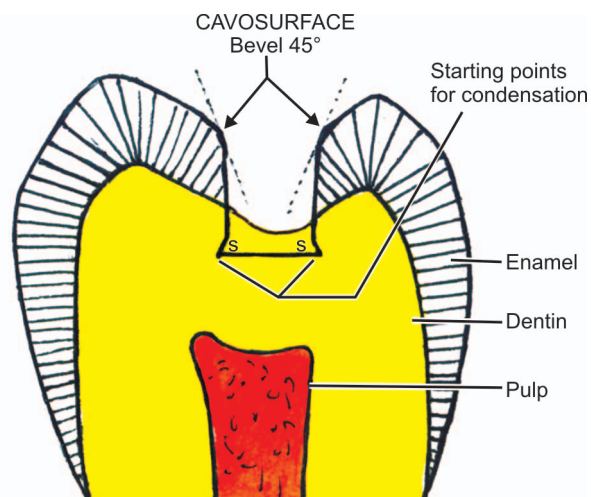
Black's principles of cavity preparation require careful attention and adherence for successful restoration. But the cavity should be made as small as possible. All walls must be supported by sound dentin. Outline form should be such as to avoid unsightly restoration.

Inadequate healthy dentin will provide poor resistance resulting in tooth fracture. To avoid loose restoration proper retention by sharp line angles and point angles is essential in the cavity. For proper condensation of gold starting point or convenience form must be present. Starting point or convenience points are made with very small (no. 33½) inverted cone bur. Cavity must be properly cleaned to stabilize the first increment of gold. For isolation use of rubber dam is a must as even the breath of the patient can contaminate the gold surface to make it non-cohesive.

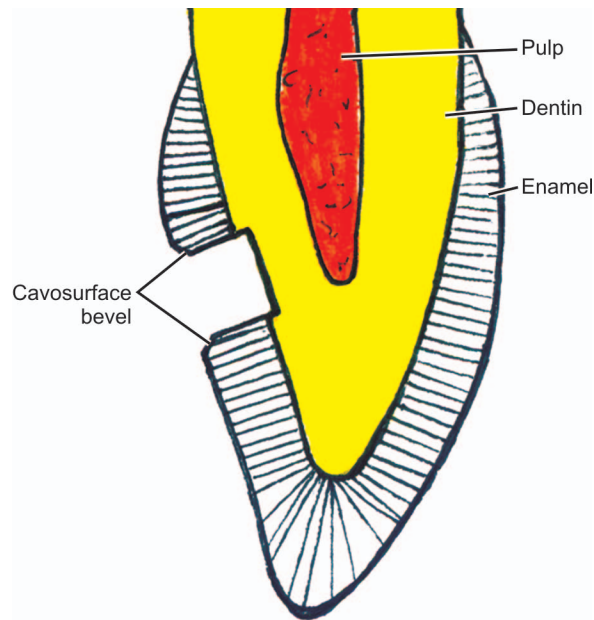
## Class I Cavity Preparation

The marginal outline form is simple and circular. If there is some defective fissure, cavity may be oblong and triangular, etc. The external walls of the cavity must be parallel with respect to each other. Mesial and distal walls may be slightly diverging in case of extensive occlusal preparations. Walls must be parallel and undermining and weakening of marginal ridges must be avoided.

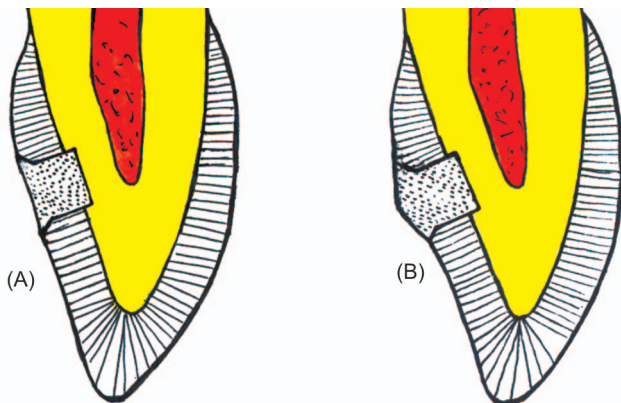
If additional retention is required in the dentin, undercuts are placed in the facial and lingual walls by small inverted cone bur. Small bevels may be placed at the cavosurface margins for easy finishing (Figs 32.7 to 32.9).



**Fig. 32.7:** Class I cavity prepared for direct gold filling restoration with bevels of cavosurface margins. 'S' at pulpoaxial line angles are the starting points for condensation



**Fig. 32.8:** Outline form of lingual pit cavity of maxillary incisor. Cavosurface bevel is given and axial wall is in dentin



(A) Correct lingual concavity with restoration of direct gold filling.  
(B) Incorrect over extended lingual contour.

**Fig. 32.9:** (A) Correct lingual concavity with restoration of direct gold filling, (B) Incorrect over extended lingual contour

### Class V Cavity Preparation

The outline form of the cavity for direct gold is trapezoidal. As the tooth is narrow in the gingival area, the gingival outline is shorter. The occlusal margin should be straight and parallel to the occlusal surface of the teeth. The mesial and distal margins should be straight and when they meet at the occlusal and gingival margin, the angle formed should be acute and obtuse respectively. For retention, convergence is given in the

occlusal and gingival walls. The acute axio-gingival line angle is very important for retention (Figs 32.10 to 32.15).

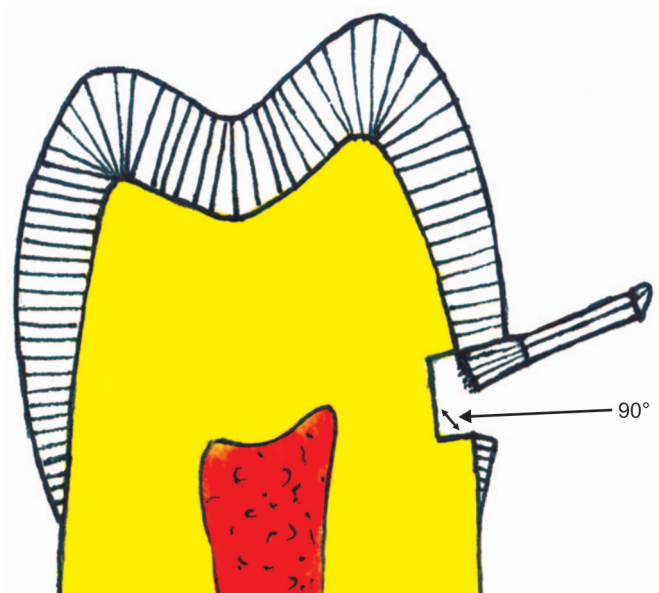
The incisal outline may be modified to follow the contour of the soft tissue mesiodistally when caries extends occlusally. In straight marginal outline, cavity instrumentation is difficult.

### CLASS III CAVITY PREPARATIONS

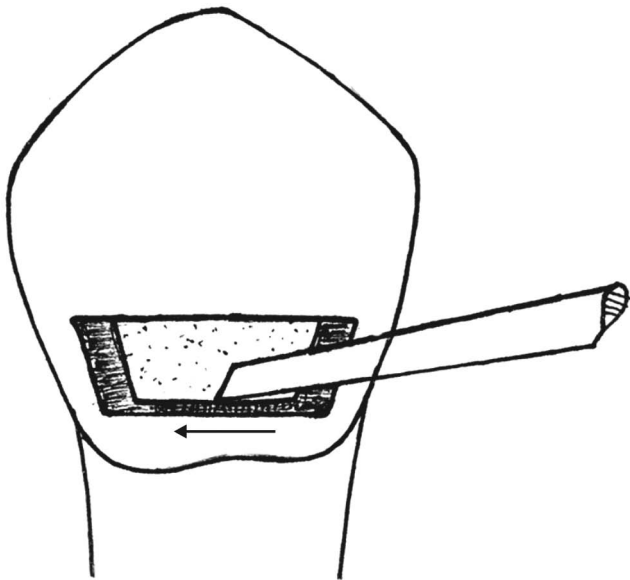
For class III cavity various designs like Ferrier design, Loma Linda design, Ingraham design, Lund and Baum design and Woodburg designs have been suggested. The first three are more popular. Class III preparation is made after separation of teeth. To approach the lesion the teeth should at least be separated by 0.25 mm. After the desired separation has been obtained the separator should be removed as early as possible to prevent damage to the periodontal ligament.

#### a. Ferrier Design

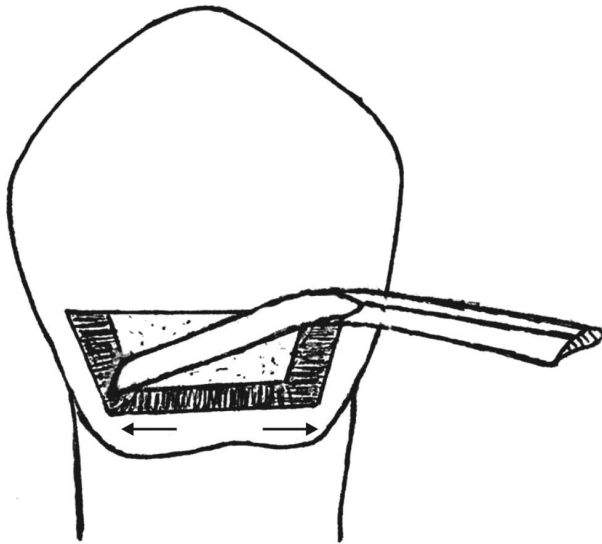
This is indicated for small areas of demineralization on distal surfaces of anterior teeth, which are less visible. In this the lesion is approached from the facial side with no. 1/2 round bur, then no. 33 1/2 inverted cone bur is used. The preparation is made triangular in shape.



**Fig. 32.10:** Class V preparation, occlusal wall preparation to produce cavosurface bevel in enamel



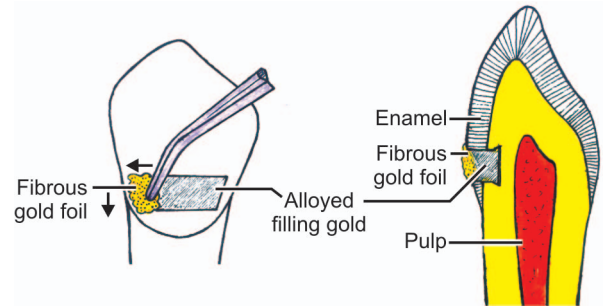
**Fig. 32.11:** Class V preparation, planing the cervical wall with the help of chisel



**Fig. 32.12:** Class V preparation, refining the cavity walls and angles

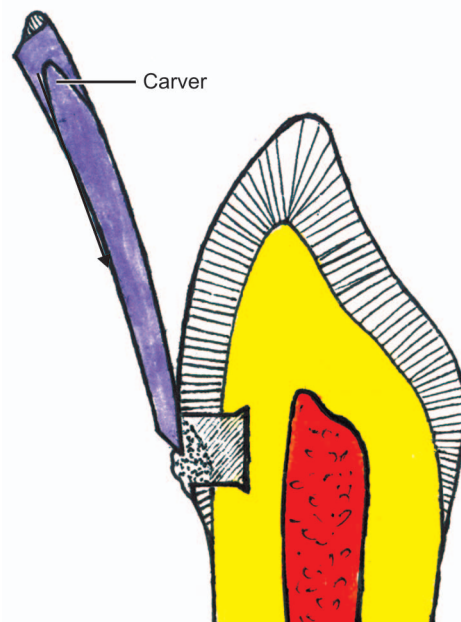
The incisal margin is kept cervical to the contact area to provide access for instrumentation. It meets the facial and lingual margins in a smooth curve.

The axial wall is flat in all the directions and is about 0.5 mm deep into dentin. The axial wall provides resistance form. The inward sloping dentin of the gingival wall the incisal undercut in the dentin and sharp line angles and point angles provide retention.



**Figs 32.13 and 14:** Restoration of class V cavity. Initial placement of fibrous gold started from one area on the cavosurface margin.

Restoration of class V cavity. Condensation completed with sufficient contouring and excess for finishing. Excess material is removed during contouring and finishing



**Fig. 32.15:** Restoration of class V cavity. Carver moving gingivally to remove the excess gold by shaving

Linguoincisor curve provide convenience for condensation of gold. All enamel margins are slightly bevelled to remove only overhanging unsupported enamel rods.

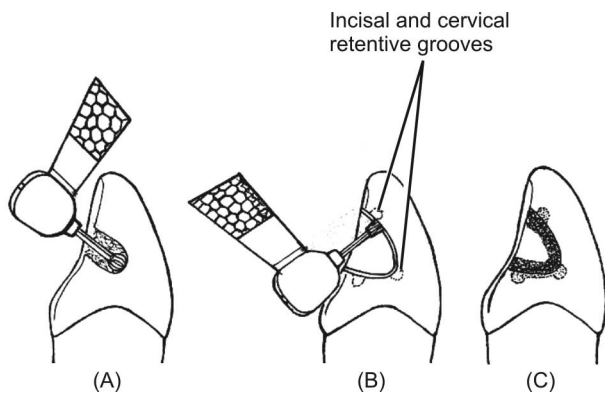
*Restoration:* The filling is done mostly with small sized pellets of gold foil or rarely with gold foil combined with mat gold.



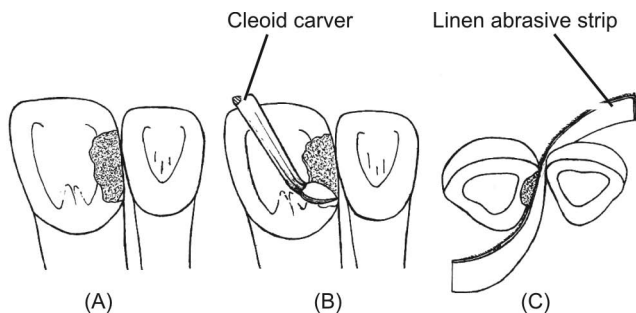
### b. Loma Linda Design

The preparation is done from lingual approach. It is used in cases where lingual marginal ridge is involved, facial surface has to be preserved and esthetics is most important. No bevelling of the cavosurface angle is done. For retention small grooves are made in three opposite directions (Fig. 32.16).

**Restoration:** The matrix is placed if the facial surface is also involved. Starting point is inciso-labio-axial point angle (Fig. 32.17).



**Fig. 32.16:** Class III cavity preparation for direct filling gold restoration (proximal view) (A) Entering with round bur into carious lesion from the lingual surface, (B) Final cavity preparation making flat labial wall using inverted cone bur, (C) Condensed initial increments of filling of encapsulated powdered gold into the cervical and incisal locks and retentive points. The condensation continues along the labial wall



**Fig. 32.17:** Class III cavity restoration (A) Completed condensation of direct filling gold restoration (lingual view), (B) Initial finishing with cleoid carver to remove the excess material (lingual view), (C) Establishing the interproximal contour and finishing with abrasive strip (Incisal view)

### c. Ingraham Design

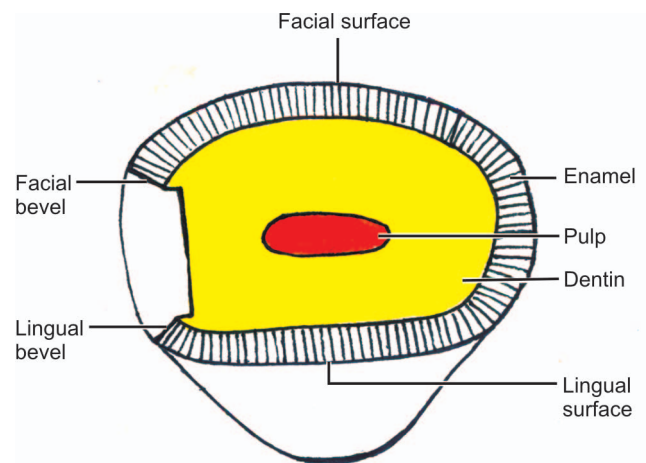
It is used in incipient proximal lesions where esthetic is most important, caries susceptibility is low and oral hygiene is good. The general shape of the cavity is of a parallelogram which is mostly confined to the contact area and the lesion is approached from the lingual side with a very small inverted cone bur.

**Restoration:** A piece of mat gold of the size of labial wall is placed on the labial wall and condensed. Over it gold foil is placed in the incisolabial corner and condensed till the cavity is filled.

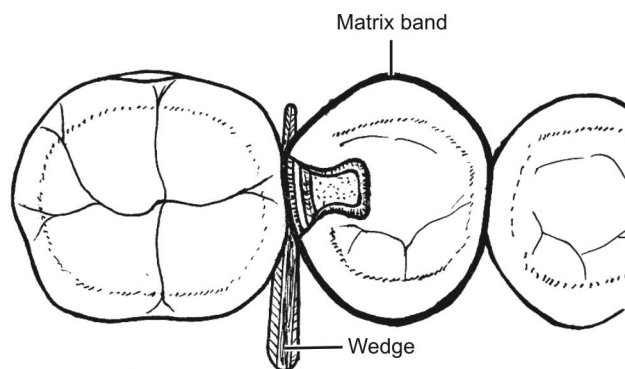
The gingival margin is straight faciolingually and is at right angle to the long axis of the tooth. It meets the facial margin by making an obtuse angle, while at the lingual margin, the angle is acute. For retention, sharp obtuse angles may be made in the facioaxial and linguoaxial line angles into the dentin. Retention can also be obtained by an undercut box which is placed in the dentin faciolingually (Fig. 32.18).

### Class II Cavity Preparation

The isthmus and marginal ridge area are very conservative in width. The proximal box is slightly smaller than that of amalgam restoration. Buccal and lingual walls should be extended for easy manipulation and finishing. The gingival margin should be just cervical to the contact areas. Retention grooves may be placed in dentin of the proximal and gingival walls.



**Fig. 32.18:** Class III cavity preparation in maxillary incisor shown in horizontal cross-section of crown. Facial and lingual cavosurface bevels are placed in enamel



**Fig. 32.19:** Matrix is prepared for class II cavity direct gold restoration in mandibular second premolar, utilizing an annealed copper band. Wedge is placed to adapt the copper band on proximal surface and to support the forces of condensation

It should involve adjacent deep pits and fissures. The deep pits and fissures which are separated by at least 1 mm thick healthy dentin are filled as separate cavities. Retention is provided by sharp line angles and point angles unlike amalgam and composite where they are slightly rounded.

**Restoration:** To serve a proximal missing wall use of a matrix band is a must (Fig. 32.19).

If cavity is small and margins are close to adjacent teeth, then to avoid the gold from spilling during condensation, use of matrix band and wooden wedge may be adequate. If embrasures are open, copper band or Tofflemire band is used which can be stabilised by acrylic, high fusing compound or light cure resin.

For restoration mat gold along with gold foil is used. The mat gold is cut to the size and shape of the gingival seat, is degassed and placed into position. It is properly condensed into line angles and point angles. Next pellet is placed against the facial wall of the proximal box and condensed. In the same way on the lingual wall of the proximal box condensation of next pellet is done. In this way proximal box is filled upto pulpal wall of occlusal part. Now along with the proximal box occlusal box is also filled upto 2/3 level. The remaining cavity is filled with gold foil.

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# *Restorations of Badly Decayed and Broken Down Teeth*

There are certain principles, designs and modalities of cavity preparations for different restorative materials used for the restoration of teeth. But there are certain conditions in which the affected tooth is very badly mutilated so much so that it cannot be restored by using the same principles and modalities as used to restore a moderately damaged tooth. Thus, in order to restore a badly broken down tooth certain principles have to be followed which are essential for the success of procedures.

## **INITIAL MANAGEMENT**

The following preliminary steps are taken prior to finalizing the design.

1. Status of pulp-dentin organ and peridontium should be evaluated
2. All the frail undermined enamel should be removed
3. Carious enamel and dentin should be removed.
4. Pulpal and axial walls close to pulp should be covered with intermediary bases like calcium hydroxide [ $\text{Ca}(\text{OH}_2)$ ]

## **BIOLOGICAL EVALUATION**

The nature and dimension of the remaining tooth structure should be evaluated as it will help to build up a final restoration in a most acceptable manner. To achieve this following procedures should be followed.

### **Evaluating Stress Patterns in Posterior Teeth**

There are some stress concentration areas in tooth like marginal ridges, oblique ridges and cusps, etc. If they are present in the remaining tooth structure then they should not be disturbed while preparing tooth for restoration. There are some weak areas like thin dentin

bridges, nearby bifurcation, cementum etc. which are present in the remaining tooth structure. They should not be involved in restoration. Stresses are maximum at second premolar and first molar teeth and minimum in teeth opposing bridge, pontic and denture, thus the design for a restoration should be such that it can withstand these stresses.

### **Evaluating Vitality of the Tooth**

A pulpless tooth is brittle in nature and has less strength than a tooth with vital pulp because of dehydration of dentin. Thus, a tooth in question should be checked for vitality using various pulp vitality tests. If tooth is pulpless, i.e. endodontically treated, then various factors are to be considered like technique used to obturate a root canal, dimensions of pulp chamber, number of root canals as all these factors will influence the retention methods. Endodontically treated teeth that have adequate periodontal support and have been appropriately restored have been shown to make valuable contributions to long-term treatment. The bulk of the remaining tooth structure that surrounds the opening of the root canal should be evaluated as this is an area of maximum stresses.

### **Radiographic Evaluation**

Radiographic evaluation is done to have an idea about nature and dimensions of remaining enamel and dentin and their relationship with pulp chamber and root canals. Radiographs also help in giving an idea about investing periodontal support of tooth.

### **Dimensions of Resisting Planes**

As far as possible flat planes perpendicular to occlusal forces should be created as this is the most effective

resistant form in tooth preparation for any restorative material. They should be located ideally peripheral to the pulp chamber and root canals, so that they may have sufficient tooth bulk apical to them. They can be of one of the following forms-pulpal floor gingival floor, tables, ledges and shelves.

### Crazing and Surface Deformities

Crazing is formation of small cracks on the surface of the tooth. These craze lines should be evaluated as they can lead to partial or complete fracture. They can be diagnosed using transilluminating light or indicator dyes. If crack tooth syndrome (vertical split or crack in the tooth involving the pulp due to which transient acute pain is occasionally experienced while chewing) is confirmed, then it should be included in the treatment.

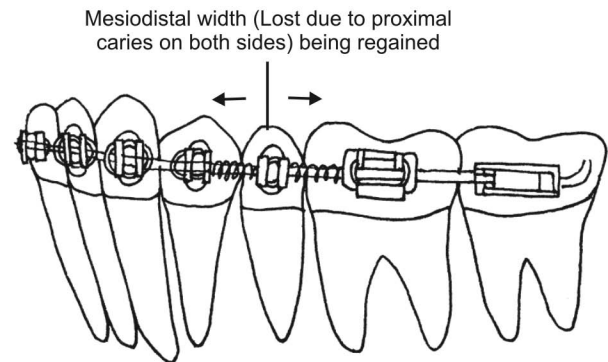
If surface defects are present adjacent to the peripheries of destruction then they are involved in the tooth preparation.

### Proximal Drifting of Tooth

If mesiodistal dimension of the dental arch has been reduced due to proximal drifting of tooth because of its own structure loss, then it can't be restored to its original dimensions or contour. In order to restore the tooth in question to its original dimensions, space regaining is necessary. This can be done by regaining the space by orthodontic tooth movement. If space regaining is not possible then the tooth has to be restored to a reduced dimension in the available space (Fig. 33.1).

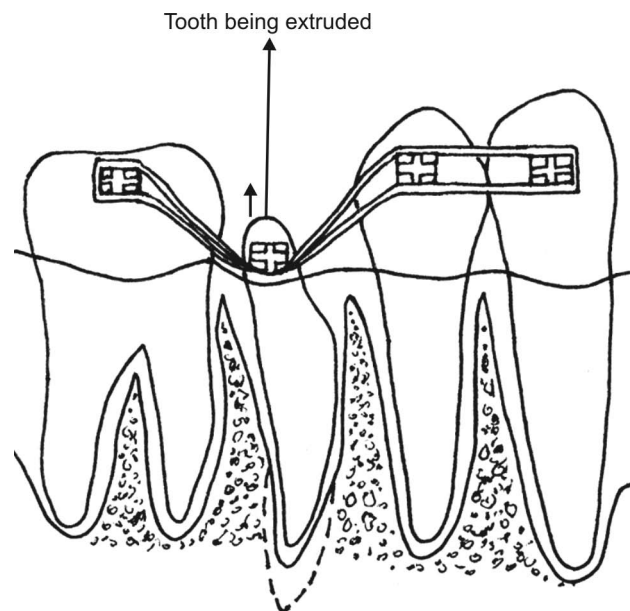
### Relation of Gingival Margin Location to Periodontium

Relation of peripheries of tooth destruction with the gingival margin should be evaluated. If destruction is located supragingivally then there is no need to alter the periodontium. If destruction is located apically to gingival cervice but suprabony then gingivectomy is performed to expose the apical limit of defect. If the apical limit of defect is infrabony then a full thickness mucoperiosteal flap is raised along with osteotomy to expose the defect. If apical limit of defect is infrabony and there is sufficient bone support then intentional extrusion of tooth is done to expose the apical limit of



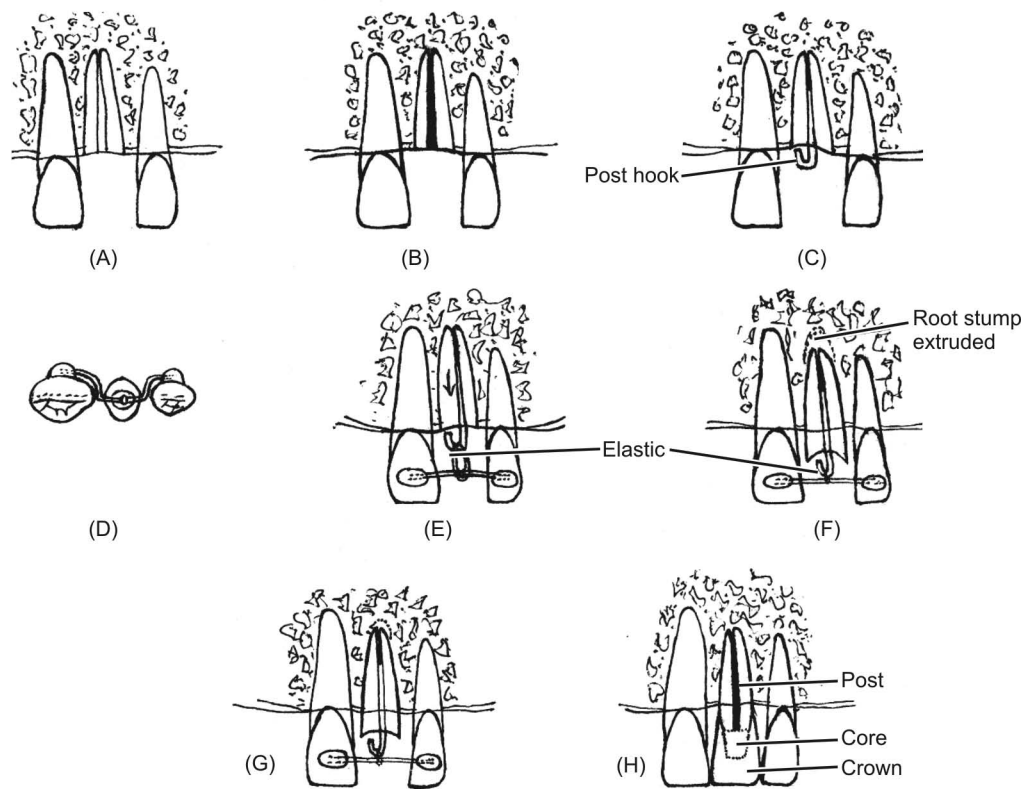
**Fig. 33.1:** Regaining of lost mesiodistal dimension of second premolar due to proximal caries by coil springs in fixed appliance between second premolar and adjacent teeth before restoration

defect. This is done with the help of elastic and hook (Figs 33.2 and 33.3).



**Fig. 33.2:** Use of elastic bands to extrude the  
a. damaged crown to expose the apical limit of the defect and for proper retention of the restoration.  
b. Intruded tooth (root of intruded tooth shown with broken lines)  
c. Similarly in reverse order the elastic bands can be used to intrude the extruded out tooth.





**Fig. 33.3:** Fractured root stump extruded with elastic and restored with post, core and crown. (A) Fractured root stump of left maxillary central incisor at gingival level (B) R.C.T done (C) Post hook is cemented in the root canal (D) Steel wire is bent and the ends are anchored with GIC or light cure composite on the adjacent teeth. With an elastic post hook is attached to the wire so that the elastic pulls the root stump incisally (occlusal view) (E) Labial view of (D) (F) Root stump is extruded out of gingiva 3 to 5 mm (G) Bone formation takes place at the apical end of the root stump (H) Post, core and jacket crown prepared and cemented

### Badly Mutilated Teeth with Affected or Treated Periodontium

Badly mutilated teeth which had undergone periodontal therapy may create certain difficulties and have to be kept in mind while planning a restorative procedure. These problems should be evaluated prior to restoration as they may affect the treatment modalities. Bone loss because of periodontal disease may cause a problem achieving a retention. If furcation is being involved in the area of destruction then it may lead to special designing features. In case of tapering root the tooth preparation for a proximal lesion will have a very thin dentin bridge axially, thus having a chance for pulp exposure, also gingival floor will be narrow, thus reducing the retention. Cast restorations are almost

impossible to be made in such cases. This situation may lead to modifications in restorative design. Moreover loose teeth may complicate the instrumentation. Hemisectioning or root amputation can be done in case of periodontally affected multirooted tooth.

### MECHANICAL EVALUATION

Mechanical evaluation of lost tooth structure is done for designing the retention-resistance features of the tooth preparation. The following factors are considered.

### Nature and Dimensions of Destruction

Buccolingual and mesiodistal destruction poses both retention and resistance problems while occlusoapical

destruction presents more retention than resistance problem. If the stress concentration areas of tooth are lost then it poses a great retention problems, this requires special restorative design features including bulk, flat floor and proper fulcrum for the center of restoration. Special retention features should be added to the stress concentration areas.

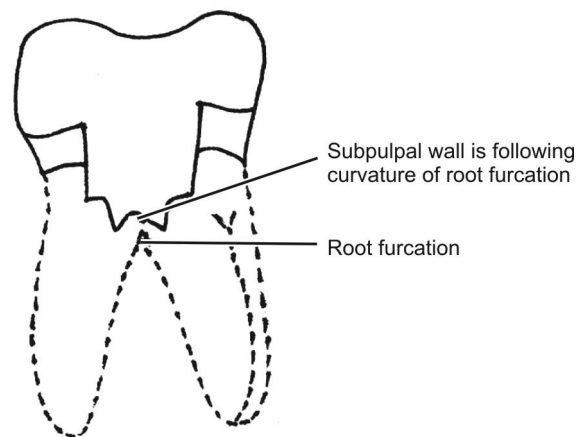
### Cusp Loss

Partial or complete loss of cusp should be evaluated as loss of cusp poses a major retention problem, thus creating a need for special designing in tooth preparation for restoration. It all depends upon the nature and dimensions of cuspal involvement. Whether a functional or non-functional cusp is involved both create a retention- resistance problem, but it is more with the non-functional cusp as stresses on it are more displacing and destructive than on the functional cusp. Also width of cusp lost in relation to intercusp distance is very important. The width can be measured in buccolingual direction in all posterior teeth and in buccolingual and mesiodistal direction in tricuspid teeth. Loss exceeding  $1/2$  to  $1/3$  of the inter cuspal distance is detrimental to resistance form. The buccolingual partial loss of cusp poses more problems rather than mesiodistal or occlusoapical loss as it may cause both retention and resistance problems while mesiodistal loss cause only resistance problem and occlusoapical loss creates retention problems with slight resistance problem. Length of remaining part of cusp is also important in relation to width of cusp.

Also the occlusogingival length of axial wall in relation to surrounding wall should be in ratio of 1:2. Less than this creates a retention and resistance problem. In case of complete cusp loss various retention methods should be incorporated in design which are required to replace stress concentration areas. In onlay retention may be obtained from pulp chamber after RCT (Fig. 33.4).

### Loss of Marginal Ridge

Marginal ridges are the elevations of enamel that form the boundary of the occlusal surface of a tooth. Their partial or complete loss affects the resistance and retention form and thus they should be evaluated. The width of partial loss in relation to intercusp distance is very important. If the ratio of cusp loss and ridge loss are same, then the design for restoration will be the



**Fig. 33.4:** Retention for onlay has been obtained from the pulp chamber. Subpulpal wall which is close to furcation must follow apico-occlusal curvature of the root furcation in the horizontal direction to prevent perforation

same, but if the ratios are farther apart then there will be different design features for cusp and ridge. Intact and thick ridges are helpful in resistance form. Dimensions of the lost ridge depend upon the contact with opposing cuspal structures. If thinned part of marginal ridge are not involved in the centric relations, then any thickness as much as 0.5 mm is adequate but if the thinned part of marginal ridge comes in contact with opposing cuspal structures, then at least 1.5 to 2 mm thickness is required. Oblique or transverse ridges should not be crossed unless they are 0.5 mm thin or less. If it becomes necessary to cross a ridge, then crossing should be confined to thinnest part of the ridge. Complete loss of ridge requires reinforcing protective measures as it is usually accompanied by destruction of critical intercusp dimensions of destruction.

### Axial Angle Loss

Loss of partial or complete axial angle (s) poses a major resistance problem as most of the stresses are concentrated on these areas and also it is difficult to immobilize the restoration without involving external surface of adjacent tooth. Thus, it is important to evaluate the loss of axial angle. Problem is more with loss of nonfunctional side as compared to loss of functional side as stresses are more concentrated on this side. Also terminal losses are more harmful than midway losses because restorations replacing these parts will be under continuous stresses as they will be a part of occluding cuspal element. Loss on occlusoapical

## 340 *Textbook of Operative Dentistry*

direction is more damaging while loss in horizontal direction is least damaging. Loss in pulpal direction may lead to pulpal exposure.

### **Junction Between Clinical Crown and Clinical Root**

Extent and nature of destruction should be evaluated at the junctional area. As this is a stress concentration area, the stress condition will be aggravated if there is decrease in tooth bulk in one or more of the three possible directions. The most detrimental loss is axially. If there is complete loss of clinical crown then the retention modes should be placed inside root and a newly created junction between clinical root and clinical crown is formed of the restorative material.

### **Evaluation for Occlusal Disharmony**

Occlusal abnormalities like cross bite, tooth extrusion, intrusion, rotation etc, that can functionally change the relative position. The stress pattern of cuspal structures should be evaluated so that necessary changes can be made into the design for tooth preparation. It is better to undergo orthodontic treatment prior to restorations but if it is not possible then these abnormalities should be included in restorative design. Design and instrumentation for the restoration should be modified according to these abnormalities.

### **Abutment for Prosthesis**

It is possible that restored tooth can be used as an abutment for prosthesis. In that case the restoration should be designed such, that it can bear the additional stresses concentrated on the restoration and the remaining tooth structure.

### **Splinting**

During an overall treatment the tooth to be restored can be splinted to another tooth, i.e. splintee or can be used as a splinter. Splinter restoration accommodates more stresses than the 'splintee' which are dependent upon the adjacent tooth to which it is splinted, for resistance and retention form. Amount of bone support around the tooth and amount of lost tooth structure, decides whether the tooth be a 'splinter' or a 'splintee'.

### **Periodontal Support**

For the restoration to be strongly resistant to bear occlusal forces there should be sufficient tooth support

as periodontal tissue and supporting bone are responsible for dissipating most of the occlusal forces acting on the tooth. Thus for proper resistance the ratio for relative length of restored clinically crown to the clinical root should be at most 1:3. The lesser the ratio is, the stronger will be the resistance form of the entire tooth to the loading stresses.

### **Parafunctional Habits**

Parafunctional habits like bruxism, tobacco chewing, pipe smoking etc. should be evaluated and necessary changes in the restorative design should be done, if required.

### **Tilted Tooth**

Destructed tooth can be tilted due to several reasons like missing adjacent teeth, loss of proximal tooth structure, or periodontal diseases. The tooth should be corrected prior to restorative management with the help of orthodontic appliances. Proper diagnosis should be made with the help of cast analysis, cephalometry etc. for proper enlignment of tooth. Several factors should be considered while going in for an orthodontic treatment. These include amount and direction of tilt, amount and condition of investing bone, root surface area of the tilted tooth and changes in tooth relationship occurring after uprighting of tooth. Tooth movement can be brought either with the help of removable appliances or with fixed orthodontic appliances.

## **RESTORATIVE DESIGN PLANNING**

Planning for restorative design depends upon the various factors as described earlier in this chapter. Mostly amalgam, metal ceramic and other cast restorations are permanent restorative materials used to restore badly decayed and broken down posterior teeth. Therefore, the restoration should be designed, keeping in mind the properties of these restorative materials. Following principles should be followed in the restorative design.

### **Restoration of Total or Partial Cuspal Loss**

Total or partial cuspal loss can be managed by using either amalgam or metal ceramic or cast restorations, depending upon the nature and dimensions of cusp loss. The ideal cusp length: width ratio is one or less, if

it is more than 2 or 2 on the functional side then the non-articulating cusps should be capped with amalgam and if the ratio is 3 or more on the non-functional side, then the articulating cusps should be capped or replaced with amalgam. In case of cast restorations which depends upon tooth structure in terms of their retention form, as in comparison to amalgam which depends both on its retention and resistance form on remaining tooth structure, if ratio is more than 1 on functional side, the cusp should be capped with cast restoration, while if ratio is more than 2 on non-functional side, the cusp should be capped with cast restoration. In case of amalgam restorations, the intercusp width should not exceed  $1/4$  to  $1/3$  distance. If it exceeds  $1/2$  of intercusp width then cusp protection is mandatory, also if axial wall length is less than  $1/3$  the length of surrounding wall, the cusp should be capped.

In case of cast restorations, if the cavity width is more than  $1/3$  the intercusp distance then cusps should be capped.

### **Restoration of Lost Axial Angles**

As axial angles are stress concentration areas, materials to be used must be in bulk while replacing axial angles in comparison to other areas. Margins should be right angled if amalgam is to be used and obtuse angled if casting is to be used for restoration. Auxiliary retentive devices can be used like collars, skirt, reverse secondary flare if casting is to be used as restoration, but these modes should not be placed at the site of lost axial angle rather placed at nearby locations.

### **Management of Lost Marginal Ridges**

Both amalgam and castings can be used to replace lost ridges, but castings are better options as they can protect and reinforce these areas using bevels, skirts, counter bevels in their design.

### **Restoration of Lost Crown Root Junction**

Management of partial or complete loss of crown-root junction can be done either with the help of amalgam or cast restoration, however more bulk is required in case of amalgam.

### **Restoration of Craze**

Management of cracks on enamel depends upon the number and extent of cracks. If there are signs of crack

tooth syndrome or if cracks are numerous, they should not be included in the tooth preparation. These teeth can be restored by giving an amalgam foundation and then restoring the tooth with cast restoration like onlay or full veneer crown. If cracks are limited and penetrate enamel only, then either enamelectomy or enameloplasty could be done, depending upon the extent of crazing. Following points should be considered while restoring such a tooth.

- A. Components of tooth structure- restoration complex as stress- receiving and stress inducing components should be kept away from involved area of teeth.
- B. Preparation margin should be such located so that they do not contact the opposing teeth during mastication.
- C. Margins between different parts of the preparation must be rounded.
- D. Restorative material should be in bulk in the isthmus areas to prevent fracture.

### **Management for Tilted Tooth**

Tilted tooth can be uprighted in proper position using an orthodontic force, but in case if it is not possible to upright a tooth by orthodontic treatment or tooth is slightly tilted, then a tooth can be restored as it is, by keeping following factors in mind. The maximum loading stresses to be applied should be allowed to direct away from the direction of inclination, this can be done by changing the tooth occluding anatomy in the restoration. The occluding surfaces should be such that the forces that act on the restoration should not cause further tilting.

### **Additional Retentive Devices Like Cemented Pins or Post**

These additional retentive and resisting devices are indicated in following conditions:

- a. In extensive cervical lesion.
- b. In which it is necessary to join the partially separated segments together.
- c. Where there is need to reinforce the junction between the anatomical crown with the anatomical root.

### **Retention Features for Badly Decayed Tooth**

Various retentive features have been described in this and other chapters. In addition certain rules that should be followed for retentive features like (a) recognizing



## 342 Textbook of Operative Dentistry

the displacing forces acting on restoration. (b) Retention modes should be used according to the material used for restoration. (c) They should not produce additional stresses on remaining tooth structure. (d) They should be placed in the areas having sufficient tooth bulk. (e) Retention modes should be used along with auxiliary retentive means. For retention there should not be a compromise on the biological integrity of involved tooth structure, also every segment of the preparation should have its own retentive modes, so that no part of restoration should depend upon another part for retention as far as possible.

### Resistance Features for Badly Decayed Tooth

Certain rules should be followed while using resistance features. They are as follows

- A. Restorative material should be placed in bulk for resistance,
- B. Planes in tooth preparation should be right angled to bear masticatory load.
- C. They should be in harmony with the occlusion without disturbing the integrity of tooth structure. The floor of the preparation should be kept flat as much as possible to withstand masticatory and dislodging forces.

### Management of Endodontically Treated Teeth

Endodontically treated teeth are more brittle. They require special design features for restoration. Cast restorations are more suitable. Pin or posts can be used if coronal tooth tissue is missing. Badly broken endodontically treated teeth can be restored using amalgam foundation, covered by cast restoration. Amalgam is considered more superior than composites to be used as foundation because it has following properties:

- a. minimum porosity,
- b. maximum adaptability to retention modes,
- c. more strength,
- d. color contrast to tooth structure, and
- e. better bonding with luting cements as it can be completely dried from moisture, beside it can be easily removed from subgingival margins.

All these properties are missing in composites (For details refer Chapter 35).

### Management for Periodontically Treated Tooth

Badly broken, periodontically treated teeth are much more difficult to restore. For restoration of periodontically treated teeth, the restorative design should be made, keeping following factors in mind:

- a. Gingival margins should be placed supragingivally
- b. While using castings as restoration auxiliary retentive means like skirt, secondary flares, etc. should be incorporated in the design.
- c. Margins should not be placed in the furcation.
- d. For all restorations the preparation walls and floor should follow the same configuration as treated root surface.
- e. The gingival margins and finishing lines that come close to a furcation should follow the apico-occlusal curvature of furcation in the horizontal direction.
- f. Gingival floors which are immediately occlusal to furcation should be accompanied by mesial and distal flat ledges or gingival floor away from furcation, so that no force will concentrate stresses in the furcation tooth structure.
- g. Occulsoapical contour especially facial and lingual axial contour should be less pronounced than usually found in teeth not previously affected with periodontitis.

This will improve plaque control around the peridontium. The horizontal axial contour of the restoration should follow the same contour as the treated tooth surface to maintain the integrity of the peridontium.

### SPLINTING

Splinting of teeth is done in order to immobilize a loosened tooth and to share the stresses. Corner tooth with a long root should be included in a splinting assembly and splint should be designed such that the stronger tooth will receive the applied force before the weaker. Tooth can be splinted if there is mobility exceeding three (seven as per new mobility index (NMI) of authors) degrees or if tooth is required to play a major mechanical role in the dentition. It can also be splinted to improve resistance and retention form or can be splinted to prevent further tooth movements after orthodontic or periodontic treatment.

Various types of teeth splints are used. They are basically of two types.

- A. Provisional splint
- B. Permanent splint

### Provisional Splint

Provisional splint can be of two types:

- i. Removable type
  - a. Occlusal splint with splinting wire.
  - b. Hawley's appliance with splinting arch wire.
- ii. Fixed type.

### Intracoronaral

- Amalgam restoration condensed together.
- Amalgam and wire.
- Amalgam, wire and resin.
- Composite resin and wire with or without enamel etching.
- Pin retained wire, chain and composite resin.

### Extracoronaral

- Orthodontic soldered bands.
- Wire and resin retained through enamel etching.
- Stainless steel bars retained by enamel conditioning and composite resin.
- Brackets and wire.

### Permanent Splint

- i. Extracoronaral—Partial or full veneer crowns soldered together.
- ii. Intracoronaral—Inlays or onlays soldered together.

### Foundation for Badly Decayed Teeth

Foundation of either amalgam or composite resins is given prior to restoring a badly decayed tooth by cast restorations. Amalgam is more superior material for foundation than the resins, below the cast restorations due to following reasons.

- a. Foundation can be indicated in nonvital endodontically treated tooth in which all nonfunctional cusps or half or more functional cusp are to be replaced.
- b. They are indicated in cases where marginal or crossing ridges are involved or one of the axial angle on nonfunctional side is being lost.
- c. They are indicated in badly decayed tooth where more than half of the structure is lost and in tooth having deep axial cervical lesion.

Foundations are advisable because of the following reasons.

- a. They can replace the lost tooth structure, thus minimizing the amount of casting material.
- b. They support the weakened tooth structure thus help in bearing stresses.
- c. They also aid in enhancing the retention for cast restoration.
- d. They help in simplifying the design of cast restoration, by building up badly broken down tooth to a fairly regular shaped tooth.

### PRINCIPLES FOR RESTORING BADLY DECAYED ANTERIOR TEETH

Restoration of anterior teeth is esthetically important, as a successful anterior restoration from the patient's point of view is a tooth restored with contour and color that, for all practical purposes, makes the restoration invisible. While restoring a badly decayed anterior tooth, many of the design features are same as mentioned for the posterior teeth.

The material of choice for restoring a badly decayed anterior tooth are tooth-colored restorations. An anterior esthetic restoration loses its conservative nature when there is loss of a major amount of tooth tissue necessitating extracoronaral coverage. Although non-tooth color materials are not used for restoring anterior teeth but there are few exceptions where they can be used. These situations are as follows

- a. The distal of the cuspids,
- b. Foundations for cast restoration
- c. Substructure for porcelain super structure.

All the factors considered for the evaluation of posterior teeth are considered also for evaluating, preparing and restoring the decayed anterior tooth. It is essential to evaluate a remaining tooth structure for determining the material being used to restore a tooth. As an anterior tooth has limited tooth structure, thus all the conditions regarding forces acting on tooth; the stress concentration areas, i.e. lingual marginal ridges, incisal angles and ridges, cervical areas, distal area of canine, etc. and the weakened areas, i.e. undermined enamel, should be evaluated prior to making a choice for restorative material. Besides these some other factors that should be considered are as follows:

- a. Malocclusion;
- b. Possibility of creating a gingival floor;
- c. Crazeing;
- d. Dimensions and nature of remaining tooth structure.
- e. Esthetics, and

## 344 Textbook of Operative Dentistry

- f. Phonetics should be essentially considered while planning a restoration for a badly decayed anterior tooth.

Usually we can restore an anterior tooth by using either of the three following choices.

1. Tooth can be built up with a foundation and then covered with a protecting tooth colored restoration.
2. Tooth can be restored by covering with a tooth colored restoration without any foundation build up.
3. Restoring a tooth with tooth colored material.
1. Tooth that can be restored by building a foundation and then covering with a reinforcing/protecting restoration uses amalgam as a foundation and porcelain or porcelain fused to cast metals as a covering restorations.

They can be used in the following conditions

- a. Where more than 50% of the tooth structure is lost
  - b. Where there is loss of two incisal angles together with more than half the proximal surface of the tooth.
  - c. They can also be used for tooth having multiple crack lines
  - d. Where tooth is to be used as an abutment for fixed prosthesis or partial denture.
2. Porcelain or porcelain fused to cast metal can be used to restore a tooth without foundation build up. They can be used where there is not much loss of tooth structure and remaining tooth structure has necessary axial length to retain the reinforcing-protecting restoration. They are also indicated in those situations where direct tooth color materials are unable to achieve a desired results.
  3. For restoring the tooth with direct tooth-colored materials, the material of choice is composite resins. They are indicated for the situations which do not necessitate the use for ceramics. Certain factors should be kept in mind while restoring a tooth with direct tooth-colored materials. These factors are as follows:
    - a. The tooth to be restored should have intact incisal angle;

- b. The preparation should have both labial and lingual walls.
- c. Nature and dimensions of enamel should be evaluated as enamel can be used for retention in some tooth colored restoration.
- d. Also as much as possible the gingival floor should be created at right angle to the long axis of the tooth while preparing a tooth for restorations.

It has been observed that the bonded ceramic inlays and indirectly fabricated bonded Resin bonded ceramic (RBC) inlays have the ability to restore fracture strength of teeth to values similar to those of sound and unrestored control teeth.

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## *Emergencies and Postoperative Complications*

A patient can be treated as a dental emergency if there are one or more of the following conditions.

- a. Severe dental related pain.
- b. Severe bleeding
- c. An immediate danger to the dentition or surrounding tissues.
- d. Pulp involved fractured or evulsed tooth
- e. Fractured jaw(s)

The above situations require emergency treatment. Cases of postoperative complications are soft tissue lesion at the restorative site, faulty occlusal relationship or proximal relationship.

Dental urgency differs from dental emergency in that it does not require immediate attention and is mostly seen during routine patient examination. Example of dental urgency is asymptomatic deep carious lesion. The diagnosis and treatment plan for the condition is made by chief complaint, visual inspection, palpation, sensitivity tests and radiographs. Most of the emergency problems are tooth or soft tissue related.

### PROBLEMS RELATED TO TOOTH

The following are important tooth related problems.

1. *Odontalgia*: Odontalgia means pain in a tooth. Tooth pain is not localized, it may be referred to other areas. For diagnosis, clinician should rate the patient's description of pain and then clinically verify the symptoms. The causes for dental pain are as follows.
  - a. *Irreversible pulpitis*: The tooth is sensitive to hot and cold sensation and percussion. Radiograph may show damage or carious lesion involving the pulp, widened periodontal ligament or periapical radiolucency. To provide relief and drainage, root canal treatment should be done.
  - b. *Acute apical periodontitis*: While biting on hard objects, pain in a tooth may be induced due to damage to the periodontal ligament. After diagnosis periodontal treatment and root canal

treatment followed by cast restoration may be indicated.

- c. *High filling or restoration*: Usually next day of the filling or restoration if there is pain in the tooth which become severe on occluding the teeth, the cause may be high spots. High spots on filling or restoration are reduced after giving local anesthesia, if required.
- d. *Tooth hypersensitivity*: It can be due to pulpal irritation during cavity preparation, which causes temporary reversible pulpitis. The pulpal irritation can be avoided by using coolant spray. Hypersensitivity may be due to recent restoration. Proper lining or cement base helps in preventing this problem.

If after tooth preparation dentin is left exposed, tooth sensitivity will occur. Provisional restoration after tooth preparation helps in preventing the sensitivity. If margins of a restoration of a prepared tooth are short, sensitivity will occur in the supragingival area. Root sensitivity is experienced after dental prophylaxis or periodontal treatment. Sometimes the dentin of the tooth in the cervical areas may be exposed due to gingival recession, erosion or abrasion.

- e. *Cracked tooth syndrome*: The tooth cusps may appear to be healthy and firmly in position, but sharp pain will occur when pressure is applied to the cusp during mastication. The cusp fracture can be diagnosed by making the patient bite on small, rubber polishing wheels or an orange (soft) wood stick. If cracked tooth is identified with vertical crack, splinting by horizontal wiring is done to hold the fractured portions firmly in correct position. Root canal treatment followed by full crown cast restoration must be done to relieve the pain and prevent the complete fracture of the cusps.



## 346 Textbook of Operative Dentistry

- f. *Maxillary sinusitis*: Pain in the maxillary posterior teeth may occur due to infection of the maxillary sinus. Toothache occurs because the root apices are close to the wall of the maxillary sinus.

Treatment is the use of antihistaminics and antibiotic therapy.

2. *Traumatic injury*: Traumatic injury can cause the following.
- a. *Fractured teeth*: If a tooth is fractured in many pieces and it is non-restorable, then it should be extracted. If tooth is restorable according to clinical signs and symptoms, appropriate restoration must be done after root canal treatment.
  - b. *Displaced teeth*: The displaced teeth may be replaced in their proper place. If patient is young and there is no root fracture, intruded teeth re-erupts in about three months. If a tooth fails to show any eruption in a period of three months, orthodontic treatment may be done to reposition the tooth. If labial or lingual displacement occurs, the tooth should be brought back to position under local anesthesia and then it should be immobilized.
  - c. *Avulsed teeth*: After the accident, the avulsed permanent teeth of young adults may be reimplanted. The tooth is replaced in the socket and stabilized by splinting and within two weeks, root canal treatment should be done or it may be done before reimplantation.
  - d. *Root fractures*: Fracture of the root may be either horizontal or vertical.

If horizontal fracture occurs at the gingival margin, middle or apical one third, root canal treatment with intra-radicular splinting with gold alloy or silver point in the root canal in place of GP point is done. This will stabilize the fractured portions.

Mostly, fracture of the root in the long axis of the tooth occurs in teeth restored by means of post. To prevent vertical fracture, the length of the post should be to 2/3rd of the root length. If the tooth is otherwise healthy then vertically fractured portions are splinted with stainless steel or gold wire after correctly positioning them. This wiring is done at two to four places in the horizontal direction. If root canal treatment is not already done then it is done after proper splinting. (For details

refer 'Textbook of Endodontics with MCQs' by the authors).

## PROBLEMS RELATED TO SOFT TISSUE

- a. *Faulty proximal contact*: If proximal contact is open, food impaction results due to which pain, gingival inflammation, interproximal caries and loss of alveolar bone take place. Interim relief can be given by further opening of the contact so that no food is retained between the teeth. The treatment is to replace the restoration with proper contacts.
- b. *Improper contours*: Over contoured proximal restorations impinge on gingiva causing inflammation, soreness and food entrapment. The proximal contact should be recontoured or the restoration should be replaced to rectify the error. If buccal or lingual surfaces are overcontoured, there will be problems like cheek biting or retention of the plaque. Undercontouring will cause injury to gingiva during mastication.
- c. *Gingival and periodontal abscess*: There is swelling and pain in the gingival tissues. The tooth is tender on percussion. The treatment is drainage of the lesion. If the problem is accompanied by endodontic abscess, root canal treatment should be done.
- d. *Lacerations and ulcerations*: Lacerations occur due to improper use of instruments, which are treated according to severity which ranges from observation to suturing. Ulcerations can be due to tissue irritation from the operative procedure. If ulceration does not heal up in 7 to 10 days and a local irritant is not there, it may be due to systemic or other local disease.
- e. *Necrotizing ulcerative gingivitis*: In this condition there is severe pain and the gingival tissue is covered by necrotic grayish white membrane which when removed reveals bright-red hemorrhagic gingival tissue. Treatment is debridement, rinsing with hydrogen peroxide solution and antibiotic therapy.
- f. *Aphthous ulcer*: Lesion varies in size from 2.1 mm to 2.5 mm and mostly occurs in the mucobuccal fold, but can be found elsewhere in the oral mucosa. They are supposed to be associated with Herpes simplex virus. Treatment consists of use of astringents, antibiotics and steroids.
- g. *Foreign body reactions*: These are tissue responses to food, restorative materials and impression material. The reactions vary according to patient's resistance and type of foreign body.

If elastomeric impression material or rough acrylic is forced into soft tissue, acute or chronic inflammatory changes may occur. Amalgam sometimes causes bluish-black tattooing of the surrounding tissues.

### Reversible and Irreversible Pulpal Changes

The preservation of the vitality of the pulp is very important. In reversible pulpitis vitality of the pulp is preserved. If tooth is having irreversible pulpitis then pulp cannot regain its vitality and has to be removed. Therefore it is very important to distinguish between reversible and irreversible pulpitis (Table 34.1).

### Problems Related to Temporomandibular Joint

Due to sudden change in the vertical dimensions of the teeth there may be pain and discomfort in TMJ. This may be due to the following sudden changes.

- Excessive increase in the thickness of occlusal surfaces of the crowns and onlays.
- Sudden removal of all the crowns and onlays from all the teeth.
- Providing too thick an occlusal biting platform to compensate for severe attrition.

### Foreign Body Reactions

Foreign body reactions are a response of the body tissues to the outside materials present within or

adjacent to living body issues. Food, restorative materials and impression materials may manifest foreign body reactions in patients. Endodontic sealers, restorative materials impression materials and food particles impinging on soft vital tissues or bone and may produce acute or chronic inflammatory reactions. The factors which control these reactions are as follows:

- Body resistance
- Type of foreign body
- Amount of foreign body
- Location of the foreign body
- Type of tissue surrounding the foreign body.

### Reactions Manifested

The reactions differ from one foreign body to another foreign body and are controlled by the factors given above. The following reactions have been reported to the various materials.

- Silver amalgam:** Rarely bluish black tattooing of the surrounding tissues is manifested which does not produce any pathological changes or discomfort to the patient.
- Elastomeric impression materials, cement bases, excessive overhanging restorations, rough gingival margins of the restorations give rise to localized periodontal inflammation which gradually disappears by itself after etiological factor is removed.

**Table 34.1:** Distinguishing features between reversible and irreversible pulpal changes

| <i>Basis of diagnosis</i>       | <i>Reversible pulpal changes</i>                                             | <i>Irreversible pulpal changes</i>                                                                                   |
|---------------------------------|------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|
| 1. History                      | Recent dental procedures (e.g. cavity preparation and root planning)         | Trauma, pulp capping                                                                                                 |
| 2. Pain                         | (a) Momentary—disappears quickly as soon as stimulus is removed.             | (a) Continuous or intermittent—persists for minutes to hours after stimulus is removed<br>(b) May be throbbing.      |
| 3. External stimulus            | Required for pain sensation                                                  | Not required for pain sensation. Pain is felt without any stimulus.                                                  |
| 4. Percussion                   | Negative response unless problem is associated to occlusal stress            | In initial stage—negative. In advanced stage may be positive when concomitant acute apical periodontitis is present. |
| 5. Referred pain                | Absent, because of minimally affected pulp tissue and short duration of pain | Usually present                                                                                                      |
| 6. Effect on pain by lying down | Does not increase on lying down                                              | Increases on lying down                                                                                              |
| 7. Change in shade of teeth     | No change                                                                    | Slightly darker in shade due to intrapulpal hemorrhage and tissue lysis                                              |
| 8. Radiographic change          | No change                                                                    | Slight widening of periodontal space may be present.                                                                 |

## 348 *Textbook of Operative Dentistry*

Well finished and polished gold, titanium, stainless steel, porcelain and gold alloys are more biocompatible than other materials (For details refer 'A textbook of dental materials with MCQ' by the authors).

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## Restoration of Endodontically Treated Teeth

Restoration of endodontically treated teeth is of prime importance, as the teeth become brittle after the pulp has been removed. There is dehydration of the dentin. Such a decrease in dentinal fluids is recognized mechanically by drop in ultimate strength, an increase in brittleness, and decrease in modulus of resilience of dentin. Thus, it is important to prevent the tooth from getting fractured by properly restoring the endodontically treated teeth.

Restoration of endodontically treated teeth is of importance regarding the following:

- Restoring the lost tooth structure
- Improving the physical characteristics of tooth that have been altered after the endodontic treatment.
- Esthetics, as usually endodontically treated teeth become dull and darker in appearance.

Type of restorative procedures applied, depends upon the following factors.

- Position of tooth-anterior or posterior.
- Amount of lost tooth structure.
- Esthetics
- Age of patient.
- Economic factors

Prior to going in for a restorative procedure, the operator must consider the following.

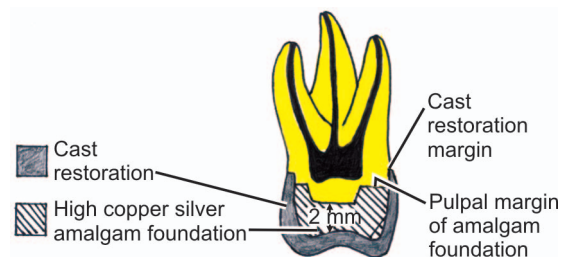
- Confirm whether the endodontic treatment has been successful or not. This can be confirmed by looking at the signs and symptoms of successful endodontic treatment, which are as follows.
  - Absence of pain, swelling or any other sign and symptom.
  - Proper apical seal with complete obliteration of root canals, without under-or-overfilling.
  - Absence of pain during percussion on the tooth.
  - Absence of pain on pressure.
  - Absence of fistula.
- Technique 1985 used in root canal treatment including the material used to obturate the canal.

- Dimension of pulp chamber relative to the dimension of the future restoration.
- Number of opposing walls in pulp chamber and their occlusal inclinations and surface dimensions.
- Number of root canals, the more the number of root canals are there, lesser are the chances of using them as an auxiliary mean of retention.
- Diameter of root canals. Larger the diameter of root canal, better will be the retention.
- Bulk of the remaining tooth structure surrounding the opening of the root canals.

### RESTORATIVE DESIGN FEATURES FOR ENDODONTICALLY TREATED TEETH

Restorative design may be planned with following considerations.

- If marginal and crossing ridges are intact then amalgam restoration can be the final restoration.
- If one or more marginal or crossing ridges are lost, then amalgam must act as a foundation for cast restoration.
- Pins and post can be used in case of badly broken down teeth.
- All badly broken-down, endodontically treated teeth should have foundation, usually in amalgam, under its restoration which is usually made up of cast materials (Fig. 35.1).



**Fig. 35.1:** Cast restoration margins must be placed on sound tooth structure. Cast restoration must be at least 2 mm away from the pulpal-apical margin of the foundation



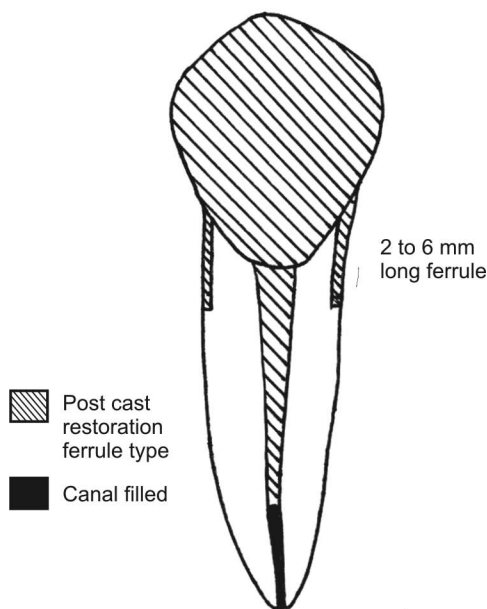
## 350 Textbook of Operative Dentistry

- E. In case of anterior root canal treated teeth, if any proximal surface is involved, then build up the tooth with a foundation form to be covered with a reinforcing or protecting restoration. Usually a ceramic or porcelain fused to cast veneer restoration is the material of choice.
- F. *Ferrule feature*: It is most important resistance feature in restoration for an endodontically treated tooth. For this the cast restoration should involve sound tooth structure at least 2 mm apical to the gingival periphery of the foundation. By applying this feature, cast restorations encompass the tooth circumferentially, bring its components together to resist splitting and to assure maximum reinforcement for remaining tooth structure (Fig. 35.2).

### TYPES OF RESTORATIONS

The following restorations are frequently indicated

- A. For anterior teeth
1. Lamination and veneering.
  2. Partial jacket crown.
  3. Full jacket crown.



**Fig. 35.2:** In endodontically treated tooth ferrule provide good resistance and retention. In this the cast restoration circumferentially encompasses the cervical one third of root to prevent splitting of the root

- B. For posterior teeth
1. Inlay covering one or all but one cusp.
  2. Onlay covering all cusps
  3. Partial cast crown.
  4. Full cast crown.

### POST AND CORE

Post and core can be built up in order to replace the lost crown structure and may be used as a foundation under the restoration. The core replaces the lost coronal tooth structure and provides bulk, cementing surface, support and retention for the crown. The dowel (post) provides support and retention for the core and should be designed so as to minimize the potential for root fracture from forces which may act on the crown. Post and core are radicular retained restorations consisting of a post or dowel with an attached core that obtains its retention and resistance to displacement from the prepared root portion of an endodontically treated tooth. While the root preparation retains the post, the core establishes retention and resistance for complete veneer crowns that restore the pulpless tooth to normal form and function. Core is built up with silver amalgam or composite resins.

There should be sufficient tooth structure to retain the post and core during mastication. Also the remaining tooth structure should have sufficient periodontal support. Excessive canal enlargement or apical extension that leaves less than 4 or 5 mm of gutta percha is avoided in order not to further weaken the tooth or risk the loss of the endodontic seal.

### TECHNIQUES

#### Restorations without Dowels

They are indicated for patients with reduced tooth structure. Where a complete crown is needed, core is placed using coronal pulp chamber for retention.

#### Restorations with Dowels

Two types of dowels are used in the restoration of endodontically treated teeth.

#### Pre-fabricated Dowels

They are more commonly used in multirooted teeth to support an amalgam or, composite core build up. They

can be subdivided into smooth or serrated, parallel sided or tapered, and tapered and threaded.

### **Custom (Cast) Post and Core**

They are indicated for single rooted teeth as well as multirooted teeth with divergent canals. They are advantageous in the sense that they are custom fit to irregularly shaped canals, not to cylindrically shaped canals, as are preformed dowels. Post and core are cast in one unit rather than two separate materials, thus they do not require auxiliary retention such as pins to retain core as in some prefabricated systems. Two techniques are used (A) direct technique most frequently used (B) indirect technique is used when there are multiple dowels and cores (Figs 35.3 and 35.4).

### **Dowel Space Preparation**

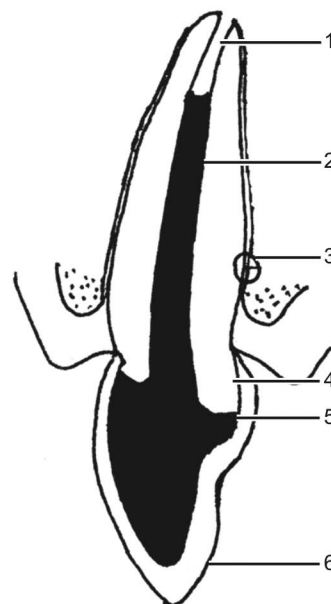
Canal should be prepared minimally upto the size of a No. 80 endodontic file. However, excessive canal preparation to provide a dowel with maximum strength weakens the root and also increases the chances of perforation.

Length of the dowel preparation should be either equal to the length of the artificial crown of the restoration or two-third of the length of root. The retentiveness of dowel is directly related to length. Increasing the length of dowel improves the retention.

### **DIRECT TECHNIQUE**

Weakened, thin and/or undermined tooth structure is removed. Remaining coronal tooth structure is sloped to the buccal and to the lingual surface to produce a ferrule effect with the dowel and core. Canal is prepared upto the size of approximately No. 90 file. The coronal end of the canal is funneled and an antirotational notch is placed with tapered bur. Plastic dowels are used to carry acrylic or inlay wax to form the pattern of the canal.

The dowel is checked for the fit at the base of the prepared canal. After resin reaches the doughy stage, the dowel is inserted into the canal. After resin is set, the pattern is removed. The coronal aspect is next shaped to resemble an ideal tooth preparation. The pattern is then invested and casted in a metal of choice.



**Fig. 35.3:** Root canal treated maxillary anterior tooth restored with one piece post and core

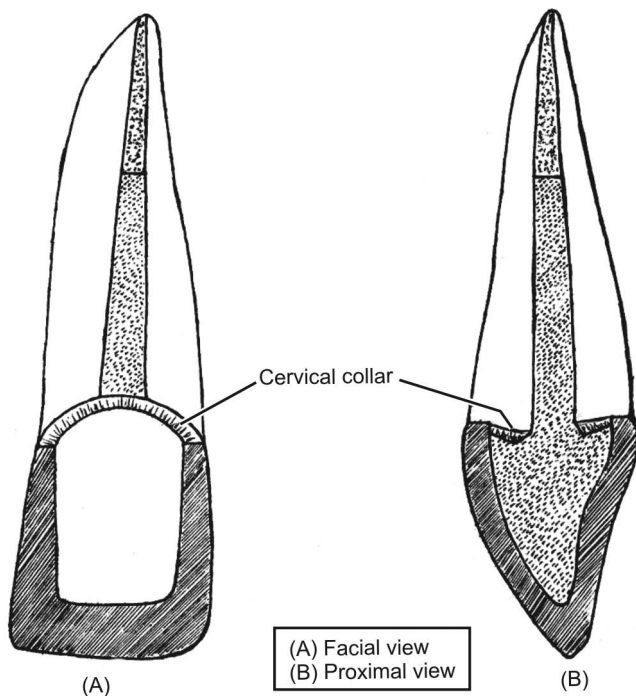
1. Apical seal is preserved with 4 to 5 mm of gutta percha.
2. Root canal post.
3. Periodontal ligament.
4. Remaining natural crown structure.
5. Core replacing missing coronal tooth structure and providing retention to artificial crown
6. Artificial crown.

### **Fitting and Cementing Custom Dowel and Cores**

Temporary cement is removed from the canal with the help of file of appropriate size. After casting is seated properly it is checked for occlusal clearance and axial contours. Canal is cleaned and then dried by using absorbent points. Cement is mixed and placed in canal, the dowel and core is also coated with cement and then placed into the tooth and maintained under finger pressure until the cement sets. Zinc phosphate, resin and glass ionomer cements are also commonly used.

### **Prefabricated Dowels**

They are cylindrical. Usually they do not resist rotation, unless they are threaded or have a serrated surface. The coronal aspect of the prefabricated dowel contains a mechanism for retaining the coronal core material, e.g. amalgam or composite resins. Prefabricated dowels



**Fig. 35.4:** Root canal treated maxillary anterior tooth with one piece post and core with cervical collar (A) Facial view (B) Proximal view

and cores are cemented similarly to the custom post and cores.

## INDIRECT TECHNIQUE

This is indicated when multiple teeth are treated, especially when the dowel and core is a coping for a tooth-supported (overdenture) prosthesis abutment. Tooth preparation is similar to the direct technic.

## ONLAYS

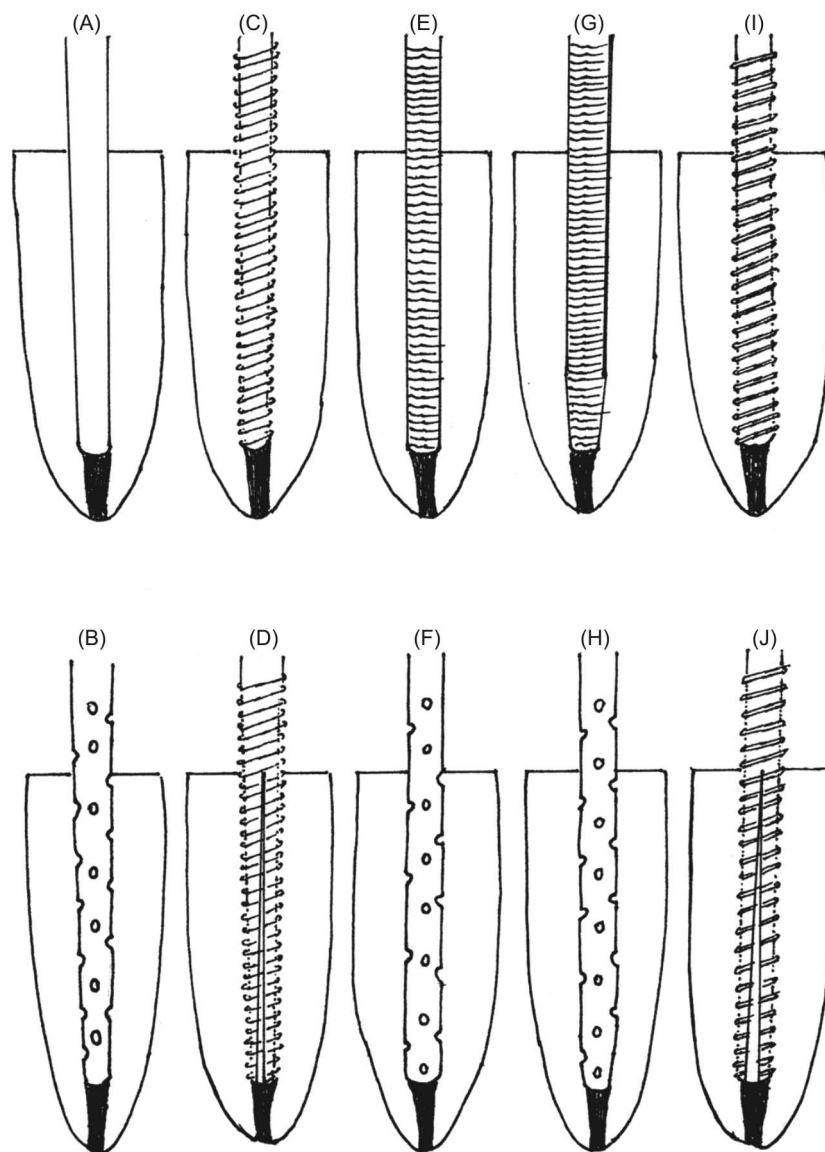
Onlays are the most indicated and universally used cast restoration for individual tooth. They cover and reinforce all of the cusps of posterior tooth and can be designed to help strengthen a tooth that has been weakened by caries or previous restorative procedures. It is partly intracoronal and partly extracoronal type of restoration, that has cusp protection and their reinforcement as the main feature. It can be designed to distribute occlusal loads over the tooth in such a manner which greatly

decreases the chances of fracture. Endodontically treated teeth become weak and are prone to fracture from occlusal forces, thus they require a special type of restoration that will provide protection from this injury, specially in case of posterior teeth, which are subjected to more occlusal stresses. When the facial and lingual surfaces of an endodontically treated tooth are intact, then it is advisable to prepare an MOD onlay rather than a full crown, as onlay will be more conservative for the health of tooth and gingival tissue. Onlay has been designed with adequate resistance form to prevent future tooth fracture. Prior to preparation of an endodontically treated tooth, the pulp chamber should be excavated up to the floor of the pulp chamber and an amalgam foundation is placed. In premolars, the canal is prepared to receive a metal post, which is placed in the canal before the impression for onlay preparation is taken. The post should extend roughly upto two-third of the total length of root and should terminate, leaving at least 3 mm of the root canal filling material at the apical portion of the root. This post will provide additional retention and will help the tooth resist forces that might otherwise cause a horizontal or oblique fracture of the entire tooth crown from the root (Fig. 35.5).

## Tooth Preparation for Onlay Cast Restoration

Initially cusps should be reduced by about 2 mm as it will improve both access and the visibility for subsequent steps in tooth preparation. Two mm deep cuts are then placed on the remaining occlusal surface usually on the crest of the triangular ridges and on the facial and lingual grooves regions. If cusps are already in infraocclusion of the desired occlusal plane, then the cusp reduction should be proportionately less.

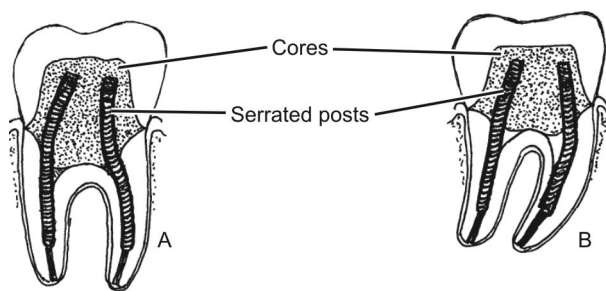
Vertical walls are created such that there is single "withdraw" path for the wax pattern and casting usually in the long axis to the tooth crown. The gingival to occlusal divergence of walls of these preparations may range from 2 to 5 degrees from the line of withdraw, depending on their height. As the height decreases, the divergence angle also decreases. After cusp reduction, there should be 0.5 mm deep occlusal step in the central groove region, between the reduced cuspal inclines and the floor of the pulp chamber. Maintaining the pulpal depth (0.5 mm), extend it in all directions,



**Fig. 35.5:** Various designs of prefabricated root canal posts

- |                                     |                                                  |
|-------------------------------------|--------------------------------------------------|
| A. Tapered smooth                   | B. Tapered notch type                            |
| C. Tapered soft threaded screw type | D. Splitted tapered self-threaded screw type     |
| E. Parallel serrated type           | F. Parallel notched surface                      |
| G. Parallel tapered end             | H. Parallel with tapered end and notched surface |
| I. Parallel threaded                | J. Splitted parallel threaded screw type         |





**Fig. 35.6:** Coronal portions of serrated posts are bent prior to cementation, to place them more strategically within the core (A and B)

beyond any carious areas. Thereafter prepare the proximal box.

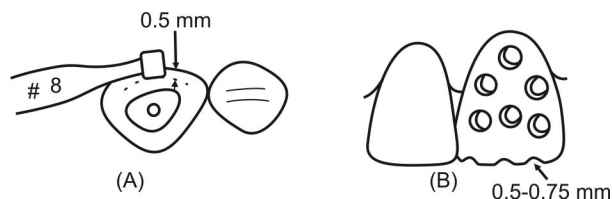
After the occlusal step and proximal box have been extended properly, any caries or previous restorative material, remaining on the pulpal and axial wall should be removed. Now, place the gingival bevel resulting in 30-degree marginal metal; counter bevels on reduced cusps, and secondary flares on facial and lingual walls of proximal box, with the help of slender, flame shaped, fine-grit bur. After beveling and flaring, slightly round any sharp angles between the counter bevels and the secondary flares (Figs 35.6 and 35.7).

## LAMINATES

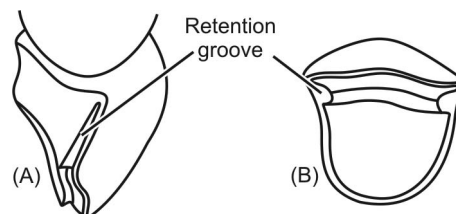
Laminates are the veneer like (but thinner than veneers) restorations. They restore the facial surface of tooth for esthetic purposes. They are made up of either composite resins or porcelain. Laminate bonding is indicated for a combination of mild to moderate anomalies of color, position, and form of the teeth. As endodontically treated teeth usually become dull and darker in shade, thus restoring anterior teeth with laminates helps in improving the esthetics (Fig. 35.8).

## PARTIAL JACKET CROWNS

Partial jacket crowns are the restorations covering two or more surfaces of a tooth. The rationale is to enhance the esthetics of the restoration and to conserve tooth structure. They are indicated in intact tooth with average crown length and normal anatomic crown form. They are contraindicated in short teeth or teeth with extensive crown restoration.



**Fig. 35.7:** Esthetic bonding (laminates)—Preparation for lamination of maxillary central incisor with damaged labial surface and irregular incisal edge. (A) Incisal view—Placement of 0.5 mm deep depressions (wells) in incisal half and 0.3 mm deep in cervical half on the facial surface with no. 8 round bur with predetermined depth penetration device # 8 (B) labial view of incisal and facial depression before lamination.



**Fig. 35.8:** Three-quarter crown preparation on maxillary canine (A) Proximal view (B) Incisal view

Partial jacket crowns are advantageous in the sense that they require less tooth reduction and are more bio-compatible to the supporting tissues.

## TYPES OF PARTIAL JACKET CROWNS

Various types of partial jacket crowns are as follows.

1. *Three quarter crown:* They restore the occlusal surface and three of the four axial surfaces not including the facial surface.
2. *Reverse three quarter crown:* They restore all the surfaces except the lingual surface. They are usually indicated on the mandibular molars with severe inclination.
3. *Seven-eighth crown:* They are extensions of the three quarter crown to include major portion of facial surface. They are generally indicated for maxillary molars and premolars where mesial surface of tooth is sound, but the distal surface is extensively destroyed by caries (Fig. 35.9).
4. *Mesial half crown:* It is actually a three-quarter crown rotated 90 degrees, preserving the distal surface of the tooth, while veneering the remaining surfaces.

## Tooth Preparation for Partial Jacket Crown

### Anterior Teeth

Three quarter crown preparation for maxillary cuspid is done as follows.

Incisal reduction is done, using a tapered bur, upto one mm at 45 degree angle to the long axis of the tooth. Then lingual reduction is done. It is completed in two steps, firstly reduce the lingual surface using round shaped diamond bur, taking care not to over reduce the height of the cingulum, shortening the lingual gingival wall. Secondly, lingual gingival reduction is carried out making a chamfer 0.5 mm deep at cervical finish line. The reduction parallels the long axis of the preparation. Thereafter interproximal reduction is carried out in three steps. First, reduce the proximal surface by moving bur from lingual to the facial surface, then establish a light chamfer finish line on proximal surface and then the contact with the adjacent teeth is broken with the help of hatchet. Lastly, proximal and incisal grooves are placed. Proximal grooves are placed parallel to the incisal two-third of facial surface. Incisal groove of 0.5 to 1 mm dimensions is placed in dentin and parallel to DEJ (Fig. 35.8).

### Posterior Teeth

Seven-eighth crown preparation for maxillary molar is done as follows.

Start with occlusal reduction by using round-ended tapered bur. Reduce the inner incline of the mesial, buccal cusp to obtain 1.5 mm occlusal clearance. Then reduce the remaining cusps to obtain 2 mm occlusal clearance. Now reduce the lingual surface to develop a chamfer 0.5 mm in depth at the cervical finish line. Then the proximal reduction is carried out in three steps. Firstly, reduce the proximal surface by moving the bur from lingual to the facial surface, then establish a light chamfer finish line on the mesial and distal interproximal surfaces. Lastly, by using the hatchet break the mesial proximal contact. Now, begin preparation of facial surface at the facial groove and extend the preparation distally around the distofacial line angle, joining with the chamfer on the distal. Mesial box is placed facial to the central groove, it should be approximately 0.5 mm from the gingival and facial finish

lines. Place a facial groove in the area of the midfacial groove. The mesial and distal walls of facial groove diverge toward the occlusal surface. Using an inverted cone bur, join the mesial box to the facial groove on the inner incline of the mesiofacial cusp. Place a narrow bevel on the mesiofacial cusp at approximately right angles to the path of insertion. At last, round the line angles, to ensure continuity of all finish lines (Fig. 35.9).

## FULL JACKET CROWN

They restore and cover all the surfaces of the clinical crown. The restorative material may be all metal, all porcelain (ceramic) or a metal ceramic combination.

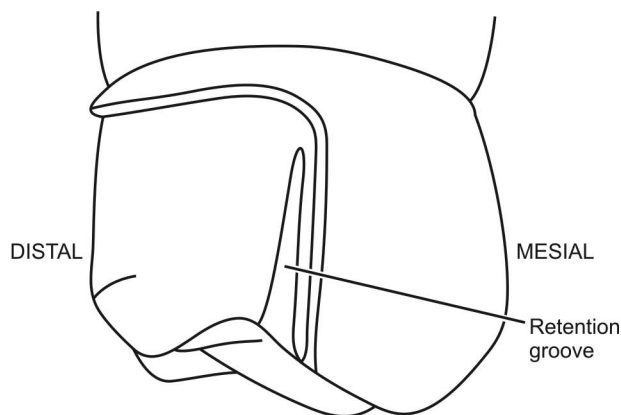
### Types of Crowns

#### Complete Metal Veneer Crown

They are made up of cast metal alloys and are usually indicated in the areas where there are heavy occlusal forces and esthetics are not of much importance.

#### Porcelain-fused-to-metal Crown

Porcelain-fused-to-metal crown consists of a cast metal substructure of a special alloy to which porcelain is fused. Usually gold is used as a substructure, but now-a-days use of base-metals is increasing. In the cervical area, it is often difficult to mask the metal, and in some cases metal is left exposed, especially in the posterior areas (see Figs 31.28 and 31.29).



**Fig. 35.9:** Seven-eighth crown preparation on a maxillary molar

### **Feldspathic Porcelain Jacket Crown**

These are translucent porcelain crowns which can be altered to match natural teeth in shade by appropriate blending of standard porcelain powders. The desired shape and contour is usually fabricated on a platinum matrix that has been adapted to a die representing the abutment preparation. They are indicated for anterior teeth, they have superior esthetic quality, but they are easily subjected to fracture.

### **Aluminous Porcelain Jacket Crown**

The core of this crown is composed of approximately 50% high-strength alumina and 50% dental porcelain. Such type of core increases the strength of restoration. Since alumina is an opaque material, this type of jacket crown does not have a translucency exhibited by the feldspathic crown.

### **Bonded Alumina Crown**

In this crown, the aluminous porcelain is bonded to pure platinum foil. The purpose of this is to improve strength by eliminating the microcracks present on the inner surface of the ceramic. The lining of porcelain remains a part of the crown.

### **Cerestore Crown**

This crown is a ceramic restoration that uses a shrink-free alumina ceramic core with an aluminous porcelain veneer. The high strength alumina core makes this crown best suited for restoration of posterior teeth. It offers superior esthetics, the only disadvantage is its complex technique for fabrication.

### **Dicor Crown**

This crown is truly castable ceramic restoration that has sufficient strength for use for posterior teeth. It is translucent and offers superior esthetics. The advantage of this type of crown is that occlusion and anatomy can be predetermined in wax pattern on an articulated cast.

### **Composite Veneered Gold Crown**

This type of crown incorporates a gold casting in which space has been created on facial side for the composite

resin. They are indicated in cases of deep bite and are contraindicated for long-term restoration.

### **Acrylic Jacket Crown**

They can be heat-cured or self-cured and are available in numerous shades for color matching. These crowns are fabricated directly on the die by using tinfoil as a matrix. Usually they do not last more than three to five years.

## **Tooth Preparation for Porcelain Jacket Crown**

### **Incisal Reduction**

Initially reduction is done perpendicular to the long axis of the tooth and 2 mm apical to the contemplated incisal edge of the finished restoration. Initially the reduction is performed in a flat plane perpendicular to the long axis of the tooth. It is now modified to a plane perpendicular to the inclination of the mandibular teeth, usually at 45 degrees angle to long axis of the tooth. This will help to tolerate the compressive forces by the porcelain.

### **Axial Reduction**

Mesial and distal areas are reduced to a 2 to 5 degree taper. Lingual convergence of anterior tooth is developed with the help of long, tapered, diamond bur. Facial reduction is performed with coarse, flat ended diamond bur. The incisal two thirds of the facial surface should be inclined lingually to provide uniform porcelain and ensure suitable esthetics.

### **Resistance and Retention Form**

Firstly, a cingulum shoulder of 0.75 mm dimension with a 2 to 5 degree taper is placed. Then a flame or wheel shaped diamond bur is used to form the lingual concavity on the anterior tooth.

### **Marginal Development and Refinement**

An end cutting bur held perpendicular to the shoulder is indicated for lowering margins. Finishing of shoulder and removal of undermined enamel is performed with the help of a chisel. Axial walls are smoothed and sharp line and point angles are rounded. Labial gingival finish line is rarely supragingival.

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## *Restoration of Noncarious Defects*

Apart from the usual process of caries, about 25 percent of tooth defects are caused by certain noncarious processes. These processes include the following.

- A. Attrition
- B. Abrasion
- C. Erosion
- D. Abfraction lesions
- E. Localized non-hereditary enamel hypoplasia
- F. Localized non-hereditary enamel hypocalcification
- G. Localized non-hereditary dentin hypoplasia
- H. Localized non-hereditary dentin hypocalcification.
- I. Discolorations
- J. Malformations
- K. Amelogenesis imperfecta or hereditary brown opalescent teeth
- L. Dentinogenesis imperfecta
- M. Trauma.

### ATTRITION

It is described as a physiological, continuous, age dependent process resulting in loss of tooth structure from direct frictional forces between contacting teeth. Attrition occurs both on occlusal and proximal surfaces. This process is accelerated by parafunctional mandibular movements, especially bruxism. In such conditions it becomes pathological.

- a. Proximal surface attrition: Attrition of the proximal contact areas leads to flat, faceted proximal contours or concave proximal surfaces, in some cases. Proximal surface attrition leads to the following.
  - i. Increase in proximal surface area, susceptible to decay.
  - ii. Difficulty in plaque control due to decrease in size of embrasures.
  - iii. Decrease in mesiodistal dimensions of teeth, leading to mesial drifting
  - iv. Reduction in total dental arch length
  - v. Increase in dimensions of interproximal space.

All these factors coupled together can lead to periodontitis.

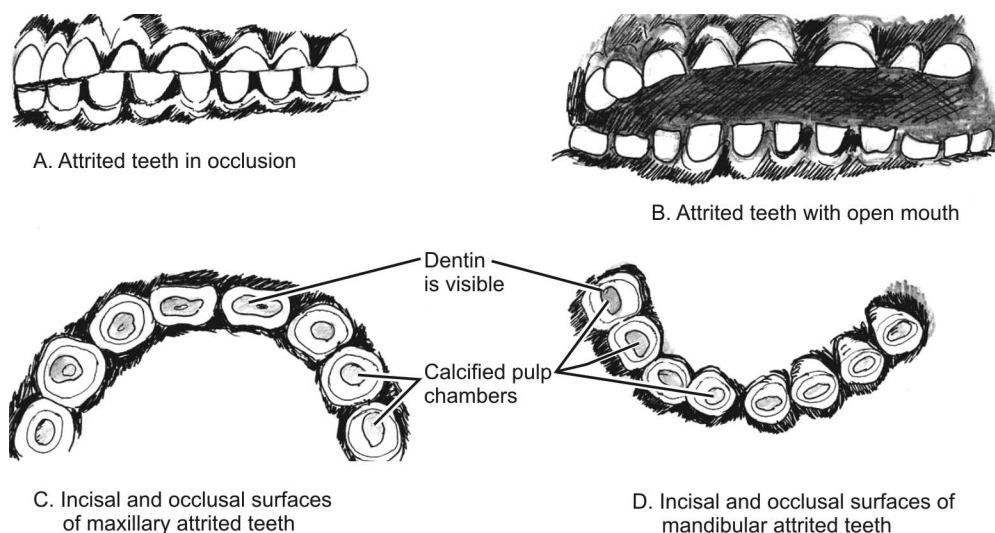
- b. Occluding surface attrition (Occlusal wear): Attrition of occlusal surfaces leads to loss, flattening, faceting and/or reverse cusping of occluding elements. This indirectly leads to the following.
  - i. Tooth sensitivity.
  - ii. Loss of vertical dimension of tooth
  - iii. Loss of vertical dimension of face (if attrition occurs rapidly)
  - iv. Interference in physiologic mandibular movements
  - v. Deficient masticatory efficiency with a predominantly horizontal masticatory movement of mandible.
  - vi. Cheek biting

All these factors can nonelastically strain the muscles, the teeth, the periodontium and the joints causing severe disturbances in stomatognathic system and temporomandibular joint (TMJ) (Figs 30.4 and 36.1).

### TREATMENT

Various modalities are involved in the treatment. These must be chosen and initiated in the following sequence.

1. Extraction or endodontic treatment of pulpally involved teeth.
2. Parafunctional habits (bruxism etc.) should be controlled using occlusal splints.
3. Diagnosis and resolution of myofunctional or TMJ disturbances.
4. Occlusal equilibration involving the following is done.
  - a. Selective grinding of teeth surfaces.
  - b. Rounding and smoothening of peripheries of occlusal table.
  - c. Creation of adequate overlap between working inclines.



**Fig. 36.1:** Severe attrition

5. Protection of exposed sensitive dentin using fluoride solution, obliteration of carious lesion and treatment of periodontal pathology.
6. Restorative modalities: Most of the restorative modalities are directed at regaining the lost vertical dimension. A temporary (resinous) restoration or a permanent cast alloy restoration should be given according to the planned increase in the vertical dimension. These restorations may involve intraradicular or extracoronary means of retention. However, most of the cases only need occlusal equilibration and non-restorative protective measures.

## ABRASION

It is a pathological process resulting from direct frictional forces between the teeth and external objects which leads to loss of tooth substance in the form of smooth saucer shaped or wedge shaped indentations on exposed cemental surfaces. The most predominantly occurring abrasion is caused due to faulty tooth brushing technique (see Figs 27.1 and 30.3). The following are the other causes of abrasion.

- a. Pipe smoking habit
- b. Tobacco chewing habit
- c. Habit of forcing a tooth pick into interdental spaces.
- d. Habit of holding nails or cutting thread through anterior teeth.

- e. Iatrogenic, such as porcelain teeth opposing natural teeth.

## MANAGEMENT

Treatment of abrasion should be carried out in following sequence.

1. Determination of the cause.
2. Removal or interception of cause.
3. Desensitization of lesion by using 8 to 30% NaF or  $\text{SnF}_2$  or ionophoresis.
4. Restorative treatment to by-pass the effect of habit and to prevent further destruction of tooth.
5. If esthetics is not disturbed there is no need to restore very shallow multiple, wide, lesions on non-occluding tooth surface. Edges of defect should be blended with the adjacent tooth surface and treated with fluoride solution
6. Restoration for esthetically prominent areas should be done using direct tooth colored restorative procedures. However in posterior non-esthetic areas, metallic restorations can be given.

## EROSION

It is defined as the loss of tooth structure resulting from chemico-mechanical acts without any specific role of microorganisms. It is one of the most predominant oral

pathologic change in which microorganisms are not involved. It is seen as sharply defined wedge shaped depression in the cervical areas of facial or lingual surfaces of teeth. In absence of any convincing etiology, it is thought to be caused by multiple factors which are as follows.

- a. Ingested acids in form of citrus fruit juices
- b. Salivary citrates
- c. Acids secreted from gingival crevice during occlusal trauma.
- d. Chelating microbial metabolic products
- e. Environmental acid fumes.
- f. Excessive tensile stresses at clinical tooth cervix.
- g. Regurgitated acids from stomach.
- h. Pattern of salivary flow.

An erosive lesion is usually glazed and has no demarcation from adjacent surface. The tooth is sensitive to chemical, physical and mechanical stimuli (see Fig. 30.4).

### Management

1. Analysis and correlation of the causative factors such as diet, habits, chronic vomiting, acidity, gastric regurgitation and environmental factors.
2. Removal of the cause
3. Preoperative study models, or photographs are prepared for future references. Wait, watch and observe the rate of progress.
4. Restorative treatment in case of extremely symptomatic or disfiguring lesions. Metallic restorations may be given except in cases of deep, badly disfiguring lesion in esthetically prominent areas where tooth-colored materials can be given.

### ABFRACTION LESIONS

These are wedge shaped defects in the cervical regions of the teeth. Their etiology is not clear but may be due to tensile stresses concentrated in this area as a result of excessive occlusal force in some remote area (see Fig. 30.5)

### Management

1. Removal of the etiology
2. Restorations as per requirement.

### LOCALIZED NON-HEREDITARY ENAMEL HYPOPLASIA

It refers to the localized defects in the crown portion of tooth caused due to injury to ameloblasts during the enamel matrix formative stage. The lesions range from isolated pits to widespread linear defects, depressions or loss of a part of enamel and are caused due to defective or no enamel formation as a result of the injury. These lesions have different colors and the discoloration increases with age. Such injury to ameloblasts may be caused by the following.

- a. Exanthematous diseases
- b. Deficiency of vitamins A, C and D.
- c. Hypocalcemia
- d. Turner's hypoplasia
- e. Traumatic intrusion of deciduous teeth.
- f. Fluorosis.

### Management

1. Selective odontotomy can be performed for very slight defects of minimal depth and size.
2. Direct tooth colored restorations utilizing several applications of conditioning acids.
3. Metallic or cast restoration for defects at occluding or contacting area.
4. Vital bleaching for discolored areas, but after odontotomy and before acid etching.
5. Laminated tooth-colored resinous or ceramic veneers for a completely disfigured lesion, both colorwise and contourwise; which is not involved in occlusion.
6. Porcelain fused to metal (PFM) or cast ceramic full veneering restoration should be given if the area is involved in occlusion or accompanied by tooth structure loss at contact areas.

### LOCALIZED NON-HEREDITARY ENAMEL HYPOCALCIFICATION

It refers to the localized defects in crown portion of tooth due to injury caused to the ameloblasts during mineralization stage. Though the enamel is normal in structure but its mineralization is defective. The affected areas appear chalky and soft to indentation, and will be stainable. The color of lesion changes fast from chalky to yellow, brown, dark brown, and /or grayish. These areas are predisposed to attrition/abrasion.

### Management

1. If diagnosed at an early stage, attempt remineralization by using periodic fluoride application and fluoride ionophoresis.
2. No odontotomy or restorations requiring etching should be done.
3. At late stages, vital bleaching, laminated veneering, composite veneering, PFM and cast ceramic crowns can be given.

### LOCALIZED NON-HEREDITARY DENTIN HYPOPLASIA

It refers to the localized defects in dentin caused due to the injury to odontoblast cells, leading to deficient or complete absence of dentin matrix deposition. The causes for these defects are same as that for enamel hypoplasia. These lesions are not seen/diagnosed as long as they are covered with enamel. Usually such defects are encountered during tooth preparation procedures.

### Management

1. Intermediary basing, as it is just an additional dimension to that part of tooth preparation which is going to be restored.

### LOCALIZED NON-HEREDITARY DENTIN HYPOCALCIFICATION

It refers to the localized defects in dentin caused due to injury to the odontoblasts during the process of dentin mineralization and has the same etiology as other type of hypoplasias and hypocalcifications discussed before. The dentin is softer, more penetrable and less resilient. Interglobular dentin is an example of such a defect.

### Management

Intermediary basing.

### DISCOLORATIONS

Discolored teeth can have far reaching effects on an individual's social and psychological well being.

Discoloration of tooth can be:

- a. Extrinsic and/or
- b. Intrinsic

The causes and examples are discussed in chapter on conservative treatment for discolored teeth.

Discoloration in enamel may occur due to hypoplasia or hypocalcification or externally or internally (systemically) applied agents. Dentin discoloration results from non-vitality, pigmentation or staining. Tetracycline discoloration is a sort of permanent staining to dentin and, to some extent, enamel. Discoloring changes in pulp-root canal system can result from pulp necrosis, internal resorption and internal hemorrhage (Fig. 36.2).

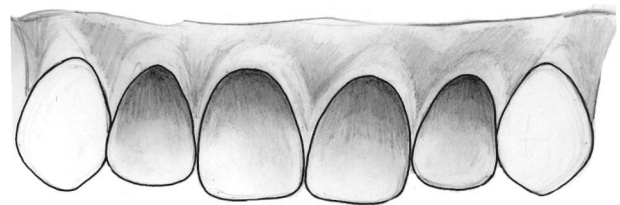


Fig. 36.2: Discoloration of incisor teeth

### Management

1. Discoloration due to extrinsic causes can be managed by sealing, polishing, bleaching, lamination and veneering
2. Intrinsic discoloration in enamel and dentin can be treated as hypoplasias and hypocalcifications.
3. Intrinsic discoloration due to non-vitality of pulp-root canal system should be treated by endodontic treatment followed by non-vital bleaching. A laminated veneer or PFM or cast ceramic veneering can be given if needed.

### MALFORMATIONS

Malformations can be micro or macro type. It is mostly hereditary in origin. The most common type of malformation is peg shaped maxillary lateral incisor. However any discrepancy between tooth size and jaw size should be differentiated.

### Management

1. Conditioning of enamel and building up of tooth with a direct tooth colored restorative material provided, the tooth is not subjected to extensive occluding forces.
2. If the affected tooth is malaligned, repositioning as much as possible should be performed before any restorative treatment.
3. If sufficient enamel is not present or if the tooth is under heavy occlusal stress, PFM or cast ceramic veneering restorations can be given.



### AMELOGENESIS IMPERFECTA OR HEREDITARY BROWN OPALESCENT TEETH

It refers to the lesion resulting from genetically determined abnormality in the formative stage of enamel, unassociated with evidence of biochemical or systemic diseases. It can be autosomal dominant, X-linked or recessive trait. Abnormality in matrix formation leads to hypoplasia while abnormality in mineralization results in hypocalcification. The lesion usually affects one type of dentition, and only enamel. The affected tooth has all features of enamel hypoplasia, hypocalcification and may show pigmented hypomaturation additionally, probably in accentuated form.

#### Management

1. In very shallow defects following may be done.
  - a. Selective odontotomy involving esthetic reshaping procedures.
  - b. Conservative non-restorative procedures.
2. In deeper defects, restorations, laminations full veneering procedures utilizing metallic, metallic based or cast ceramic restorations may be done.

### DENTINOGENESIS IMPERFECTA OR HEREDITARY OPALESCENT DENTIN

It refers to the defect(s) resulting from genetically determined abnormality in the formation and/or maturation of dentin matrix, in absence of any obvious systemic or environmental changes. Most of these defects are autosomal dominant. According to 'Shields et al' it is of three types-

- a. Type I= Dentinogenesis imperfecta occurring along with osteogenesis imperfecta.
- b. Type II= Dentinogenesis imperfecta that never occurs in association with osteogenesis imperfecta.
- c. Type III= Dentinogenesis imperfecta of "Brandywine type".

Teeth affected by Type II (most common) defect are discolored (gray, brown, yellow-brown or violet), exhibit translucent hue, have over contoured crowns and short, slender roots with extensive attrition and frequent chipping of enamel due to defective DEJ. There may be obliteration of root-canal and pulp chamber space.

#### Management

1. Early diagnosis
2. Selective odontotomy
3. Laminations and full veneering.
4. Splinting between the teeth to avoid root fracture.

### TRAUMATIZED TEETH-ELLIS CLASSIFICATION WITH MODIFICATIONS

Separation, fracture and/or loss of tooth structure as a result of trauma frequently occurs necessitating dental treatment. Trauma that leads to these mishaps can be from (1) substantial sudden impact forces (2) long standing repetitive cyclic loading forces of low strength, resulting from occlusal interferences, especially the balancing type.

Originally Ellis has classified into six classes later on two more have been added.

- Class I Simple fracture of the tooth crown, involving little or no dentin.
- Class II Extensive fracture of the tooth crown, involving considerable dentin but no pulp.
- Class III Extensive fracture of the crown, involving considerable dentin and exposing the pulp.
- Class IV A traumatized tooth which becomes non-vital with/without loss of crown structures.
- Class V Tooth lost as a result of trauma.
- Class VI Fracture of the tooth root, with or without loss of crown structure.
- Class VII Displacement (dislocation) of a tooth (teeth), without fracture of crown or root.
- Class VIII Fracture of the crown en masse, with retrievable broken crown pieces.

To this classification, two more classes, IX and X can be added, which indicate incomplete traumatic situations caused due to cyclically applied low magnitude forces:

- Class IX Traumatic injuries to deciduous teeth.
- Class X Cyclic incomplete dislocation of the tooth.
- Class XI In this enamel crack is present but fractured fragment is not separated as underlined dentin is not fractured. Incomplete fracture of the tooth or cracked tooth may be caused due to any of the following factors.
1. Trauma
  2. High speed vibratory rotating instruments.

3. Sharp deep surface grooves and fissures, improper tooth preparations with sharp point and line angles.
4. Intracoronal restorations that are loose or wide and deep (eg: MOD cavity)
5. Use of pins or posts as forced-in retention modes for a restoration.
6. Dehydrated, non-vital or hypermineralized tooth structure.
7. Habits like hair pin, needle, smoking pipe held between teeth.
8. Severe thermal cycling in the oral environment.
9. Disclusion mechanism including posterior teeth.
10. Premature occluding contacts (Balancing type)
11. In posterior teeth sharp and deep cuspal inclines and grooves.

### Management

The following is a scheme of suggested management for each class.

#### Class I

1. Smoothing of edges and peripheries of the defect.
2. Esthetic reshaping of the involved area and similar areas on symmetrical teeth.
3. Restorative treatment with direct tooth colored materials or metallic restoration depending on position and occlusal status of the tooth.

#### Class II

1. Provisional restoration of class IV type or temporary crown for anterior teeth and IRM or amalgam restoration for posterior teeth, according to principles mentioned in the chapter on restoration of badly decayed and broken down teeth.
2. Permanent restoration thereafter.

#### Class III

1. Pulp and root canal therapy (R.C.T) should be initiated immediately. It may be a direct pulp capping, pulpotomy or complete pulp extirpation.
2. A pin retained or etched enamel provisional restoration for crown build up.

3. The pulp chamber and the root canal space should be obliterated with the same material as used for crown build up, with or without pre made posts into the root canal.
4. Further follow the principles of restoration of badly broken teeth.

#### Class IV

1. Immediately initiate R.C.T, if the crown is intact.
2. If the crown is broken, proceed as class III.
3. A non-vital bleaching or a laminated veneering can be done in case of discolored teeth, but after endodontic treatment.
4. Tooth can be veneered with cast alloy or cast ceramic restoration if tooth is extensively discolored.

#### Class V

1. Replacement with a prosthesis.
2. Provisional fixed bridge with plastic denture tooth for younger patients, using two supporting rods as attachments for pontic to abutments.
3. An electrochemically etched, non-noble alloy based bridge, with a PFM pontic to be retained by conditioned enamel through a luting composite resin, can also be used as provisional prosthesis.
4. A permanent fixed bridge (cast alloy) should later replace the provisional bridge.

#### Class VI

From management point of view the root fractures can be classified as follows

- a. Horizontal
  1. cervically
  2. midradicularly
  3. apically
- b. Vertical
  1. Cervically horizontal (slightly oblique)
 

*Management:* Single visit endodontic treatment. Any periodontal surgery or intentional extrusion should be done prior to restoration of endodontically treated, badly broken down teeth.
  2. Midradicularly horizontal (or slightly oblique)
 

*Management*

    - i. In vital tooth- Immobilization is done by means of splinting.

## 364 Textbook of Operative Dentistry

- ii. In non-vital tooth root canal treatment followed by, permanent splinting to adjacent teeth, by means of reinforced stainless steel or chrome cobalt rod.
- c. Apically horizontal (or slightly oblique)  
*Management:*
  - i. If tooth is vital –Wait and watch. Periodic vitality tests are done
  - ii. If tooth is non-vital – root canal treatment followed by surgical removal of apical root fragment and apical seal
- d. Vertical root fracture  
Diagnosed by means of symptoms such as.
  - isolated periodontal pocketing next to fracture line
  - non-vital tooth
  - loosened retrograde filling or by reflection of muco-gingival flap.Root canal treatment and intracoronary splinting of fragments or hemi section (partial amputation) in multirooted teeth.

### Class VII

1. The tooth is reimplanted and splinted to adjacent teeth.
2. Wait and watch. Periodic vitality tests are done. Root canal treatment as and when required.

### Class VIII

1. The retrieved tooth pieces are cleaned and kept in sterile saline solution.
2. Root canal treatment preferably one – visit is performed if pulp is involved and pulp chamber is filled with composite resin.
3. Enamel at fracture line of the remaining tooth and broken part is conditioned, primed, joined and kept under pressure till the primer and composite sets.
4. Further reinforcing of the fragments is done by conditioning and priming the enamel at the junction and flowing composite resin over it.

### Class IX

Traumatic injuries to deciduous teeth-They are treated as per the condition.

### Class X

1. The extent and cause of periodontal break down should be detected accurately.
2. Periodontal management should be performed consisting of the following.
  - a. Removal of cause.
  - b. Occlusal equilibration.
  - c. Physiologic positioning and immobilization of tooth by means of splinting to promote healing.

### Class XI

Repair of crack line in enamel in two or three segments by slightly widening crack line with flat fissure bur no 1/4 or 1/2 by composites. It is done in segments to avoid chipping off cracked enamel portion.

For WHO classification and details of the endodontics management of the traumatized teeth, 'Textbook of Endodontics with MCQs' by the authors may be referred.

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## *Restorations and Stomatognathic System*

Stomatognathic system consists all parts of oral cavity and jaws. When tooth is restored then the restoration becomes a valuable part of stomatognathic system. The tripod of a successful restoration has three components (1) Pulp dentin organ, (2) Periodontium, and (3) Occlusion.

The basic knowledge about the components of stomatognathic system, their function, their control mechanism, the relationship between the components is very important for the practice of dentistry.

The stomatognathic system is composed of many organs. According to their function, these organs are related to each other. The organs are both the upper and lower jaws, the temporomandibular joints, teeth and the surrounding structures, the masticatory muscles, muscles of head, neck and facial expressions. Though all these components are not directly involved they are related to some functions like reciprocation, support, etc.

### **FUNCTIONS OF MUSCLES OF MASTICATION**

There are four main muscles which help in mastication (Table 37.1). They are as follows.

- a. Temporalis
- b. Masseter
- c. Medial pterygoid
- d. Lateral pterygoid

The other muscles which help in mastication are—

- e. Suprahyoid muscles
- f. Infrahyoid muscles
- g. Muscles of back of neck.

### **CRANIOMANDIBULAR JOINT AND LIGAMENTS**

Craniomandibular joint, also known as temporo-mandibular joint, is a ginglymo-arthrodial joint, means it does both the hinge action and sliding action. The articulating surfaces consist of glenoid fossa and

articular tubercle (eminence) and the condyle. The fossa continues anteriorly to the articular tubercle. The articular tubercle is convex in shape anteroposteriorly and concave medio-laterally. The condyle is oval in shape and convex both anteroposteriorly and mediolaterally.

The articulating disk which is known as meniscus is present between the glenoid fossa and the mandibular condyle. The disk is oval shaped and fibrous and thinner in the center. The joint is divided into two parts by the articulating disk.

- The craniomandibular ligaments are:
1. Temporomandibular ligaments
  2. Stylo-mandibular ligaments
  3. Capsular ligament
  4. Sphenomandibular ligaments

These ligaments extend from various parts of the skull and they are attached to the mandible.

### **TEETH**

#### **Location and Inclination of Teeth**

- The anterior teeth in the lower arch are located eccentrically.
- The premolars are located centrally in the jaw bone.
- The molars are positioned centrally.
- The anterior teeth in the upper arch are placed eccentrically.
- The premolars are positioned eccentrically.
- The molars are placed eccentrically.
- The upper anteriors slightly inclined distolingually.
- The premolars are slightly distally inclined.
- The molars have lingual inclination.
- The lower anteriors are inclined in a same way as the upper anteriors.
- Lower premolar and molars have a slight distofacial inclination.



**Table 37.1:** Functions of muscles of mastication

| S. no. | Temporalis                                                | Masseter                                                              | Lateral Pterygoid                                                                                     | Medial Pterygoid                         | Suprahyoid                            | Infrahyoid                  | Muscles of back and neck                                                                                                                    |
|--------|-----------------------------------------------------------|-----------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|------------------------------------------|---------------------------------------|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| 1.     | The main function is to retract and elevate the mandible. | The main function is to supply power for the closure of the mandible. | The superior head is attached to the meniscus and the inferior head is attached to the condylar neck. | Elevation of mandible.                   | Helps in stabilization of hyoid bone. | Immobilizes the hyoid bone. | They stabilize the mandible so that the elevator retractor and protractor muscles can act properly. They can rotate the mandible laterally. |
| 2.     | Rotation of the mandible.                                 | Secondary function is protraction and retraction of mandible.         | The superior head helps in forward movement of the meniscus.                                          | Rotation and Protraction of mandible     |                                       |                             |                                                                                                                                             |
| 3.     | While closing, it strengthens the mandible.               |                                                                       | Inferior head depresses and rotates the mandible.                                                     | Strengthens the mandible during closure. |                                       |                             |                                                                                                                                             |

Both curve of Spee and curve of Wilson are convex for the upper arch and concave for the lower arch. The curve of Spee is an anteroposterior curve whereas curve of Wilson is seen mediolaterally. (buccolingually)

### Relation of Teeth to the Musculature and Corner of the Arch

If the tooth is located near the insertion of a muscle then it bears more pressure. So the second premolar and first molar bear the greatest stress because of the lateral movements of the mandible. Lateral loading occurs more in the corner of the arch.

### Location of Teeth According to their Loading Resistance

If the loads are directed laterally they cause harmful effects to the teeth and to the periodontium. Lateral loads are directed to the inclined planes, whereas axial loads are directed to the cusp tips and the crest of the ridges, and to the depth as fossa and grooves, parallel to the long axis of teeth.

### Inclination of Cusp and the Concavities Present in the Maxillary Incisors and Canines

Cusps have four inclines, two in the facial side and the other two are present in the lingual side. These are also known as working inclines or balancing inclines. Working inclines are present towards the working side

of the cusp. On the other hand the balancing inclines are present towards the nonfunctional side, which is also known as balancing side.

In case of anterior teeth the inclines present towards the lingual concavity are known as working inclines. To facilitate lateral protrusive and gliding protrusive movements, the maxillary anterior teeth have a concavity in the lingual side from cingulum upto the incisal ridge.

### Proprioceptive Terminals

The sensory nerve capsules present in the investing tissues are sensitive to laterally exerted pressure. The higher the number of the nerve capsule the lower shall be the bearing power of the tooth.

### Position of Tooth in Relation to the Fulcrum of Movement

For various mandibular movements there are various fulcrums. Stress is more applied on a tooth if the tooth is nearer to the fulcrum.

## MANDIBULAR MOVEMENTS DURING VARIOUS FUNCTIONS

### Movement Along the Sagittal Plane

#### 1. Pure Protrusive Mandibular Movements Paths and Termination along the Sagittal Plane

Posselt's envelope describes the paths and termination of mandibular movements. While opening the mouth a

point should be traced on the lower incisor. Centric relation is at tracing point. When the condyles are located in their uppermost medial and anterior location in the glenoid fossa of the corresponding side. In centric relation position all the muscles of the mandible are in a state of equilibrium. Antero-posteriorly it is not a fixed point but mediolaterally and superioinferiorly it is a fixed point. Centric occlusion is the intraborder position. It is a condition when maximum stability is there and the cusps are in the maximum inter digitation position (Fig. 37.1).

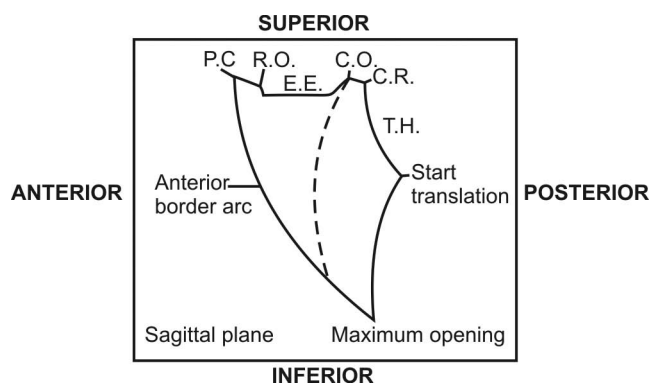


Fig. 37.1: Posselt's envelope of mandibular movements

## 2. Disclusion

Most of the functional mandibular movements are intraborder type, mandibular teeth have to be separated from the maxillary teeth for lateral or lateral protrusive movements. Disclusion is essential for posterior teeth rather than anterior teeth. Posterior teeth are not so capable of bearing the lateral load.

In the disengagement mechanism canine is the best tooth among all. Sometimes some of the anterior teeth take part in the disclusion mechanism.

In disclusion mechanism the following happens.

- A. The working inclines are involved in disclusion.
- B. Those teeth located away from the canine should be subjected to less amount of load.
- C. The tooth that is situated at a distance from the canine should be disengaged first whereas the canine should disengage last of all.
- D. Disclusion should not go beyond the mesiobuccal cusp of the first maxillary molar.
- E. During anterior excursions the anterior teeth should work as auxiliary discluding cusp. While doing protrusive movements the posterior teeth should not contact.

- F. During lateral movement the posterior teeth should act as discluding cusp.

## CONTROL OF MANDIBULAR MOVEMENTS

### Static Contact Relationship

#### A. Centric Occlusion Contacts

The lingual cusps of the maxillary teeth should occlude in the occlusal fossa of mandibular teeth, and the buccal cusp of mandibular teeth should occlude in the occlusal fossa of the maxillary teeth. In the bottom of fossa and the tip of the cusp the contact should be of greatest amount. The inclined planes should be free of contact.

For each cusp a groove is present adjacent to the fossa. The groove should be wide so that it can facilitate the escape of the opposing cusp during various lateral movement. The mandibular anterior teeth should occlude in the lingual concavities of maxillary teeth. The centric contact should be equal in all the holding cusps.

#### B. Protrusive and Working Side Contact

If the mandibular incisors are positioned labial to maxillary incisors then protrusive contact occurs. The opposing canine slopes make contact in lateral excursion. The rest of the teeth should not occlude with each other on the working side.

### Dynamic Contact Relationships

During lateral excursion, the buccal holding cusps of the mandibular teeth move along the working inclines of the buccal cusps present in the maxillary teeth. Then the cusps slide via the grooves present nearby, buccally and inferiorly. In the non-working side, initial contact occurs in the balancing inclines of the holding cusps. If the functional cusp contacts the marginal ridge, the cusp will travel along the mesiodistal incline of the ridge. When the mandible comes downward and forward the incisal edges of mandibular incisor glide along the lingual concavity of the maxillary incisors. The anterior inclination of maxillary teeth, lingual concavities determine the gliding path. Once protrusive movement is started the posterior teeth should be free of contact. In protrusive movements the slope of the canines contact. The mesial slope of lingual side of upper canine contacts the lower canine during downward forward movement.

### **Occlusion Records by Physical Manipulation of Mandible**

1. Patient should be informed the consequences of this type of manipulation.
2. If the patient moves the mandible to any side then he should experience the pressure in that direction.
3. The frequency of the movement of the clinician's finger should be proportional to the rate of the mandibular movement.
4. If there is problem in the temporomandibular joint then only some sort of deviation will be encountered during manipulation.
5. Pressure should be applied evenly on both the sides of the mandible. The mandibular position can be checked by the following.
  - a. Condyle should be in its most superior position in the Glenoid fossa. The mandible should be guided upwards and then backwards.
  - b. During this position there should be no contact of any teeth.
  - c. The centric occlusion has to be obtained by asking the patient to bite when the horizontal part of the mandible is supported.
  - d. Then lateral excursions are produced. It is started from centric occlusion. In the non-working side the mandible should be guided by the guiding hand.

After that, protrusive movement has to be made. For this the patient has to bring the mandible forward, while protruding, slight pressure should be exerted in the angle of the mandible. This is done to make contact of the condyle to the eminentia.

### **APPLICATION OF NON-TRANSFERABLE RECORD**

#### **Natural Dentition Equilibration**

Non-transferable records are obtained by using various colorful articulating (marking) ribbons which are placed in between the upper and lower teeth, while doing lateral movement and lateral protrusive movement. The teeth involved should be dried. The marking ribbon should cover the entire occluding surface, and we should be careful for the fact that there should not be entrapment of any foreign material in between the teeth and the ribbon. Normal physiologic movement of the mandible is sometimes disturbed by some teeth. The teeth which cause disturbances may have the following features:

- a. Attrited occlusal surface, tilted, supra-erupted, rotated, etc.
- b. The restoration may be less contoured.
- c. If mobile teeth are present because of diseases of periodontium.

Prior to any restorative procedure occlusal equilibration has to be done. This is done by changing the occlusal morphology of the teeth. If any interference persists it should be eliminated by mounting the upper and lower casts on an articulator.

#### **Occlusal Adjustment of a Direct Restoration**

The restoration of correct vertical dimension is very important. There should be symmetry between the anatomical shape of the cusps of the antagonists and the neighboring teeth. After applying the articulating ribbon on the interocclusal surfaces of teeth if we find heavy marks we should reduce cusp and marginal ridge and also make the fossae deeper if required.

#### **Final Occlusal Adjustment for Cast Restoration**

For occlusal and proximal accuracy all the cast restorations should always be tried in the mouth before cementation. Immediately after cementation it will not be possible to adjust the occlusion as the vibrations will weaken the cementation.

#### **Occlusal Analysis for Diagnosis Purpose**

It is valuable in checking the interferences as well as the condition of the stomatognathic system prior to any restorative procedure.

### **RECORDS WHICH CAN BE TRANSFERRED**

#### **Record of Static Relation**

Those records are transferred to the semi-adjustable articulator. The upper/lower casts can also be examined in centric relation by this articulator.

A proper hinge- axis has to be obtained. When the centric relation is being made the teeth should be free of contact. The jig is made of either acrylic or wax. The jig is prepared on the lingual surface of maxillary anteriors and it is extended on the labial surface. The jig helps to keep the mandible in centric relation during the record of this position. The jig should not be very

much thick and should not be more than inter-occlusal gap. While taking the lateral excursions they should be taken in pairs one in the right side and the other in the left side. Opposing canines on the working side should touch each other. For protrusive records the mandible should be guided in a position so that the incisors are in edge to edge relation.

For facial recordings silicon rubber base, zinc oxide eugenol, plaster, etc. are used. Facial records are taken for centric occlusion. Various articulators have been used for facial recording.

1. Hinge articulators
2. Semi-adjustable articulators

### ***Facial Records by Hinge Articulators***

When the occlusion is stable, then we can use these articulators.

### ***Facial Records by Semi-adjustable Articulators***

For recording facial records facebows are used. By facebow we record the relationship of maxilla and the cranium. When the relationship is transferred to the articulator the upper arm of the articulator with the upper cast mounted on it, will represent the maxilla.

### ***Records of Dynamic Relation***

Along with the starting and ending points the pantograph also records the other occurrences in between these points, that's why this record is known as dynamic relation record.

In case of single tooth restoration the exact hinge axis of the mandible is not necessary to establish. Mandible is guided from centric relation to centric

occlusion and from centric occlusion to centric relation for proper establishment of hinge axis of the mandible.

For stereographic tracing one maxillary clutch and one mandibular clutch are made. The central bearing point is located in the mandibular arch and three or four indentors are placed in the maxillary arch. First of all the mandible is placed in the centric relation position, after that it is moved over the centric bearing point and then to the periphery anteriorly or laterally.

Acrylic resin after mixing is placed on the incisal table of the articulator, thus anterior guidance can be obtained. The upper component is moved antero-posterior and then to an edge to edge, then again to the centric occlusion, after that it should be moved laterally right to left, and back to centric occlusion. The upper arm is moved posteriorly to adjust the horizontal overjet. After that the overbite is adjusted by moving the upper arch upwards and posteriorly. The occlusal records can be recorded in various ways, but the best method of recording depends upon individual's choice and experience. For details refer Textbook of Dental and Oral Anatomy, Physiology and Occlusion with MCQs by authors.

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Every person with discolored anterior teeth or even teeth with normal color has the desire for esthetics, whiteness and translucency in his/her teeth. The reason for discoloration of teeth may be extrinsic staining and/or intrinsic staining. Extrinsic stains are present on the outer surface of teeth, while intrinsic stains are present in the tissues of the teeth.

After careful diagnosis and case selection, for making the discolored teeth whiter, the treatment options include one or more of the following methods.

1. Oral prophylaxis
2. Bleaching
3. Microabrasion and macroabrasion
4. Lamination and veneering
5. Crowns

## EXTRINSIC STAINING

Extrinsic stains are present on the external surface of the teeth or restorations. The stains are brown, black or gray in color and are more prominent in the cervical area and the areas adjacent to the gingival tissue.

The etiological factors for the extrinsic staining of the tooth are as follows.

1. Poor oral hygiene
2. Tobacco chewing or smoking
3. Eating habits- certain types of food, oral medications containing iron or drinks can produce staining on the tooth surfaces.
4. Presence of chromogenic bacteria or fungi
5. Existing colored restorations in the teeth
6. Stains due to accumulation of plaque.
7. Stains on the tooth due to the remnants of Nasmyth's membrane.

## INTRINSIC STAINING

Intrinsic staining can be seen both in vital and non-vital teeth. Discoloration of the vital teeth occurs at the time of formation of the crown, which can be localized or

generalized. The etiological factors for discoloration of the vital teeth are as follows.

1. *Excessive intake of fluoride:* At the time of tooth formation if excess fluoride is present in the drinking water or edibles, intrinsic staining called fluorosis or mottled enamel occurs giving rise to white spots to dark brown patches on the labial enamel.
2. *Systemic medications:* Various medications, e.g. tetracycline can cause generalized intrinsic staining of the teeth. The severity of staining depends on the dosage and duration of exposure to the drug.
3. Hereditary disorders
4. Congenital anomalies
5. Metallic restorations
6. Early childhood illness associated with high fever can damage the tooth during its development causing hypoplastic defects.
7. Trauma to teeth
8. Secondary caries or leakage around existing restorations.

Discoloration of the non-vital teeth takes place individually after the eruption of the teeth. The causes for discoloration of non-vital teeth are as follows.

1. Intrapulpal hemorrhage
2. Decomposition products of pulp tissue which may be left in the chamber after root canal treatment.
3. Calcification of pulp chamber or root canal.
4. Deep caries
5. Intracanal medicaments
6. Obturation material

## TREATMENT OF STAINING

Before starting the treatment the present shade of the tooth should be shown to the patient by shade guide of tooth shades and recorded. The patient should be informed about the shade of the tooth which can be obtained, after the treatment. Esthetic imaging by computer and before and after photographs of previously treated patients with staining of teeth are excellent

adjuncts to help the patient in making an informed decision.

## ORAL PROPHYLAXIS

### Extrinsic Staining

From the tooth surface most of the extrinsic stains can be removed by routine oral prophylaxis procedures. Some superficial stains from the decalcified area and from the tooth colored restoration may not be removed from the surface of the tooth. Such stains are removed from the surface of the tooth by the method of microabrasion.

### Intrinsic Staining

Intrinsic discolorations are caused by deeper internal stains or enamel defects and are more difficult to treat than extrinsic discolorations. Discoloration of vital teeth occurs at the time of crown formation and usually involves several teeth, while in non-vital teeth, discoloration of individual tooth takes place after eruption of the tooth. The tooth discolorations are corrected or improved by microabrasion, macroabrasion, bleaching, lamination, veneering and crowning.

## MICROABRASION AND MACROABRASION

In microabrasion and macroabrasion the superficial stained areas and defects of vital teeth are abraded away. These are conservative alternatives for reduction and elimination of superficial stains and discolorations. In both of these techniques there is physical removal of tooth structure. Hence, these techniques are only indicated if the stains and defects are situated only in superficial few tenths of a millimeter in depth. If discoloration or defect persists after bleaching, microabrasion and macroabrasion then a restorative alternative is carried out.

### Microabrasion

In microabrasion there is enamel surface dissolution by 18 percent hydrochloric acid along with pumice made into a paste form and applied over the stained enamel with a spatula. The acid causes dissolution of the enamel and pumice through its abrasiveness removes superficial stains and defects. Alternately 11 percent hydrochloric acid is used with more abrasive paste using silicon

carbide particles in a water-soluble gel paste in place of pumice. It is available as a commercial product 'Prema Compound' by Premier Dental Products Co.

In microabrasion there is no bleaching but it is a purely chemical and physical removal of the tooth structure. Superficial surface defects, resistant extrinsic surface discolorations and superficial slight discolorations of fluorosis (mottled enamel) only upto the depth of 0.2 to 0.3 mm can be removed. The nature and the extent of the enamel defect or stain must be evaluated before microabrasion. Defects with deep pitting of enamel are contraindicated. This is done after proper isolation of teeth. Eyes of the operator, assistant and the patients must be properly protected against any splatter. The abrasive compound is applied on the discolored spot and is rubbed with small rubber cup revolving in a handpiece at a very slow speed with moderate firm but light pressure to remove only superficial enamel along with the defect and stain. The paste is rinsed away and the results obtained must be evaluated, whether further microabrasion is required or not. After obtaining satisfactory results the surface is polished with a fluoride containing prophylactic paste leaving smooth glossy enamel surface. A topical fluoride is applied to enhance remineralization of the enamel surface [Figs 38.1 A and B and Tables 38.1 and 38.2]

### Macroabrasion

In macroabrasion as the name indicates, little more enamel is removed. In this superficial stains and defects upto the depth of about 0.4 mm but not more than one fourth of the total thickness of the enamel are removed. It is indicated in discolored areas of the crowns having sufficient enamel thickness. In this 12 fluted composite finishing bur or a fine grit finishing diamond point in an airrotor handpiece is used to remove the stains and or defects. To avoid excessive abrading it is done intermittently with light pressure and air-water coolant is used. Extent of abrading is carefully checked intermittently. After abrading is over a 30-fluted composite finishing bur is used to remove any striations and facets. After macroabrasion, usually slight microabrasion is also done for smooth surface. Final finishing is done with a mild abrasive rubber finishing point. Air with water coolant is constantly used (Figs 38.2A and B and Tables 38.1 and 38.2).



**Figs 38.1 A and B:** (A) Mottled discolored enamel of maxillary incisors with notched incisal edges. (B) Mottled discolored enamel microabraded and incisal edges slightly trimmed to reduce notches



**Figs 38.2 A and B:** (A) Mottled discolored enamel of maxillary incisors (B) Mottled discolored enamel microabraded leading to removal of stains and discolored enamel

**Table 38.1:** Comparison of advantages of microabrasion and macroabrasion techniques

| <i>Microabrasion technique</i>                                       | <i>Macroabrasion technique</i>                                                        |
|----------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| 1. Slow in speed but with better control on abrading tooth structure | 1. High speed instruments are used hence faster and use of rubber dam is not required |
| 2. Good for children due to better operator control                  | 2. Defect removal is easier and quicker.                                              |
| 3. Enamel surface obtained is smooth, even and more glossy           | 3. Gross defects can be removed.                                                      |

**BLEACHING**

In bleaching, the lightening of tooth color takes place by application of a chemical, mostly oxidizing agent which oxidizes the organic pigment in the tooth. Bleaching usually results in lightening of shade which

**Table 38.2:** Comparison of disadvantages of microabrasion and macroabrasion techniques

| <i>Microabrasion technique</i>                                              | <i>Macroabrasion technique</i>                                                                      |
|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| 1. Proper isolation of tooth and proper protection of patient is essential. | 1. Severe and irreversible harmful results will be produced on slight carelessness of the operator. |
| 2. Gross defects cannot be removed.                                         | 2. For proper hydration of the tissues and air with water spray coolant is a must.                  |
|                                                                             | 3. Enamel surface may be uneven rough and less glossy.                                              |

generally has an approximate life span of 2 to 5 years, but in some situations the change may last more. Before bleaching, the tooth should be free of extrinsic stains, debris, plaque and calculus.

## BLEACHING OF NON-VITAL (ROOT FILLED) TOOTH

### In Office Bleaching

The bleaching of non-vital (root filled) tooth in office is basically a thermocatalytic technique. After isolation of the teeth with rubber dam the pulp chamber is opened and cleaned of all filling material to a depth of 3 mm below the gingival margin. Then the exposed root canal filling is sealed with 1 mm thick layer of a leakproof IRM sealing cement and is allowed to set. In the prepared and cleaned pulp chamber, a cotton pellet soaked with bleaching agent (superoxol or pyrozone) is placed and then light and heat are applied (by a photoflood bulb surrounded by reflectors except a small opening) from facial side to activate and accelerate the liberation of nascent oxygen and bleaching procedure.

The heat is increased to speed up the reaction because on every 30°F rise in temperature the speed of reaction is doubled. Endodontically treated teeth can withstand heating upto 165°F. Heat can also be delivered by placing a heated instrument into the pulp chamber (like ball burnisher tip attached to soldering iron) during which the pellet is saturated with superoxol. Heat is also provided by tying a cotton roll on the labial surface, saturated with bleaching solution and heated with cement hot spatula or a soldering iron. The cotton roll and the cotton pellet inside the pulp chamber are repeatedly saturated with bleaching solution after every 3 minutes. After every 15 minutes check the degree of bleaching achieved. After one sitting of 45 minutes if the result obtained is not satisfactory then a pellet soaked with bleaching solution is kept in the dried pulp chamber. Over it the opening of pulp chamber is sealed with leak proof IRM and patient is called for the next appointment. Such sittings are repeated till final result is achieved. When the final result is achieved, restore the cavity with tooth colored leak proof filling material. In a recent technique, 35 percent light-activated bleaching preparation of hydrogen peroxide is used which requires no heat (Fig. 38.3).

## WALKING BLEACH TECHNIQUE FOR ROOT FILLED TEETH

It is called walking bleach technique because the bleaching is not done in dental office. To isolate the discolored teeth place a rubber dam. Then from the access opening remove obturation material upto 3 mm



Fig. 38.3: Procedure of bleaching of root filled teeth

below the gingival line and clean the pulp chamber. Now seal the coronal portion of the root canal filling at the level 2 mm below the gingival line with 1 mm thick layer of IRM and allow it to set. Now clean the pulp chamber. Prepare the bleaching agent to fill the pulp chamber by making a creamy paste of sodium perborate by adding 2 to 3 drops of superoxol or pyrozone. Fill the pulp chamber with the paste and then seal the cavity with temporary sealing material. If bubbles are seen around the margins of the sealing material replace the sealing material because bubbles indicate marginal leakage else the patient is disposed off and recalled after 2 to 3 days. The bleaching is very active for 24 hours after which the potential of bleaching agent starts declining. The bleaching mixture is changed after every 2 to 3 days till successful bleaching of the tooth is obtained. After achieving the results fill the pulp chamber with calcium hydroxide paste and seal the access opening with temporary restorative material. After 2 weeks, remove the temporary restorative material, rinse away the calcium hydroxide paste and etch the enamel and dentin and restore the teeth with light-cured composite.

## BLEACHING OF VITAL TOOTH

### In Office Bleaching Technique

The technique of bleaching the vital tooth in office is also known as “power bleaching”. Apply vaseline or cocoa butter on the lips and gingival tissues and then apply rubber dam to provide an optimal seal around the teeth. Patient is asked to close the eyes. Eyes are protected from the heat and vapor of bleaching agent



with black cloth. Etching of the teeth to be bleached may be done with 37 percent phosphoric acid, but is not compulsory. Then tie a cotton roll of one cm diameter on the teeth over the discolored portions of the teeth and soak it with 100 percent hydrogen peroxide (superoxol) or a paste made up of hydrogen peroxide and sodium perborate. To accelerate the oxidation reaction of sodium perborate and hydrogen peroxide, apply heat on labial surface of the discolored tooth with a heating instrument or light and heat with an intense pin point light of photoflood bulb. Each treatment cycle on each day should last for 30 to 45 minutes, after which rinse the teeth with water and remove the rubber dam. The treatment cycles are repeated daily for 3 to 10 days till the discoloration is removed from the tooth (Fig. 38.4).



**Fig. 38.4:** Procedure of bleaching of vital teeth

### **NIGHTGUARD VITAL BLEACHING (DENTIST PRESCRIBED—HOME APPLIED TECHNIQUE)**

This is a 'dentist-prescribed home-applied' technique which requires less time in office and very few sittings. For the arch to be bleached an alginate impression is made and poured in cast stone. To accommodate the bleaching agent apply 2 mm thick layer of cast stone on the cast on the surfaces of the teeth to be bleached. To eliminate the vestibule, modify the cast around the periphery without damaging the teeth. A sheath of nightguard material is softened and adapted on the cast by using heat/vacuum forming machine. Then trim the night guard in a smooth straight cut about 3 to 5 mm from the most apical portion of the gingival crest

of the teeth facially and lingually. Remove the nightguard from the cast and trim, finish and polish the edges of the night guard. Now insert the nightguard into the patient's mouth and evaluate it for adaptation, rough edges and blanching of the tissue. Again trim the night guard, if required.

When night guard is ready, apply 2 to 3 drops of bleaching material on the area of each tooth to be bleached in the night guard. Bleaching material is 10 to 15 percent concentrated carbamide peroxide. It will degrade into 3 percent hydrogen peroxide [active ingredient] and 7 percent urea in thick jelly form. Carbopol when added in bleaching solution the thickness of bleaching solution is increased and it also extends the bleaching process.

Then instruct the patient how to insert the night-guard. The patient should not wear the nightguard for more than 12 hours in 24 hours during which the bleaching solution is replaced after every 1 to 2 hours for quick results. After wearing the nightguard the patient should not drink liquids. Nightguard must be removed for meals and oral hygiene. Total treatment for bleaching the teeth is usually 2 to 6 weeks depending on how long the nightguard is worn and staining of the teeth. Carbamide peroxide bleaching is safe and effective (Fig. 38.5).



**Fig. 38.5:** Vacuum-formed clear plastic nightguard used for dentist prescribed home applied vital bleaching

### **Combination of Microabrasion with Bleaching of Fluorosis stains on vital teeth—Technique of Chandra and Chawla (JADA 1975)**

Chandra Satish and Chawla T.N recommended 'disk method' of bleaching of mottled enamel. This is a



**Fig. 38.6:** (A) Mottled discolored enamel of maxillary central incisors (B) Maxillary central incisors microabraded and bleached with combination of microabrasion with bleaching technique of Chandra and Chawla (JADA- 1975)

combination of microabrasion with bleaching. The bleaching solution is a mixture of the following.

- 5 parts of 30 percent hydrogen peroxide (Superoxol)—It provides nascent oxygen for bleaching.
- 5 parts of 36 percent hydrochloric acid—It dissolves superficial surface of discolored enamel
- 1 part of anesthetic ether—It helps in deeper penetration of nascent oxygen and acid for deeper bleaching.

This bleaching solution is applied on the discolored areas on the labial surface of the teeth after proper isolation of teeth and protecting the eyes of the patient (Fig. 38.4).

The fine sand paper disk (cuttle disk) dampened with the bleaching solution rotating at a speed of 1000



**Fig. 38.7:** (A) Mottled discolored enamel of maxillary incisors with notched incisal edges of central incisors. (B) Maxillary incisors microabraded and bleached with combination of microabrasion with bleaching technique of Chandra and Chawla (JADA- 1975) (C) Incisal edges trimmed and restored with composite. The residual stains have been masked by lamination done with composite.



**Fig. 38.8:** (A) Mottled discolored enamel of maxillary incisors (B) Maxillary incisors microabraded and bleached with combination of microabrasion with bleaching technique of Chandra and Chawla (JADA-1975).

to 2000 rpm is touched for 30 seconds on the discolored areas on the labial surface of the teeth, which are already wetted with the bleaching solution. This process is repeated 4 to 8 times on each sitting. Sitzings are repeated on subsequent days till satisfactory results are obtained.

Mostly, the fluorosis (mottling) stains are in the outer one-third thickness of the enamel, except in very severe cases of pitting. By this method stains are removed in less number of sittings, and the surface obtained is more smooth and has a glaze. It is a combination of microabrasion with bleaching. By this method, the superficial layer of enamel along with the stain is slightly removed by the rotating sand (abrasive) paper disk. [Figs 38.6 (A) and (B), Figs 38.7 (A) to (C), Figs 38.8 (A) and

(B). For details Journal of American Dental Association Vol. 90 (6) 1975 may be referred.

It has been reported that a prolonged bleaching regimen using home bleaching products has the potential to increase mercury release from admixed amalgam after 80 hours of bleaching.

For further details on bleaching 'Textbook of Endodontics with MCQs' by the authors may be referred.

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## *Various Designs and Shapes of Margins of Tooth Preparations and Restorations*

The designs and shapes of the margins of tooth preparation and restorations mainly depend on the properties of the restorative material and the situation of the margin. Some materials require beveling of the margins. Bevel, in the Mosby's dictionary is defined as the inclination that one surface makes with another when not at right angles. In cavity preparation, it is a cut that produces an angle of more than  $90^0$  with a cavity wall. It can be given on any wall of the prepared teeth. In another words bevel can be defined as any sudden incline between the two surfaces of the prepared tooth or between the cavity wall and the cavosurface margin in the prepared cavity. A bevel usually is sudden while a flare is gradual. Bevels and flares both are prepared to reduce the errors and improve the joint between the filling material and the tooth structure.

Various designs and shapes of the margins of tooth preparations, bevels and flares with different types of restorative materials are used for the following purposes.

- a. To increase retention, resistance, esthetics and color matching.
- b. To improve junctional relationship between the restorative material and tooth. The types of margin of tooth preparation depend mainly on the compressive strength, edge strength and tensile strength of the restorative material.
- c. To maintain the marginal seal.

### **Beveling for Composite and Bonded Amalgam Restorations**

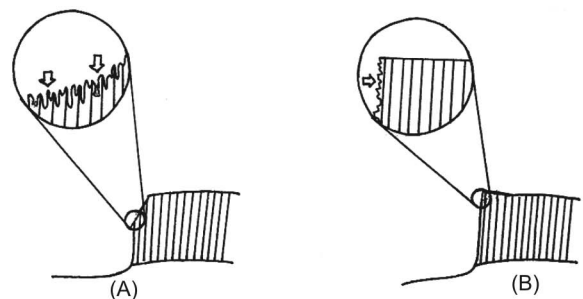
In composite and bonded amalgam restorations beveling which is done on non-stress bearing areas provide the following.

Increase the surface area of etchable enamel, enamel rods, dentin and dentinal tubules, thereby maximize the effectiveness of the bond and provide stronger bond by etching more number of enamel rods. Beveling and flaring is done on the margins which are not exposed to heavy masticatory forces. The enamel rod ends are more effectively etched, producing deeper micro-undercuts than when only the sides of the enamel rods are etched (Fig. 39.1).

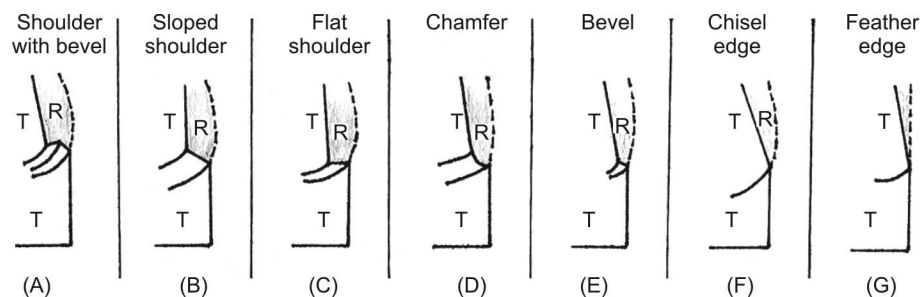
### **TYPES OF TOOTH PREPARATION MARGINS FOR CAST RESTORATIONS**

Following types of margins of the tooth preparations are used specially for cast restorations.

- (A) Shoulder with bevel (Fig. 39.2A and Table 39.1)
- (B) Sloped shoulder (Fig. 39.2B and Table 39.1)
- (C) Flat shoulder (Fig. 39.2C and Table 39.1)
- (D) Chamfer (Fig. 39.2D and Table 39.1)
- (E) Bevel (Fig. 39.2E and Table 39.1)
- (F) Chisel edge (Fig. 39.2D and Table 39.1)
- (G) Feather edge (Fig. 39.2G and Table 39.1)



**Fig. 39.1:** Etching of enamel rods (A) Enamel rod ends are more effectively etched and produce deeper microundercuts in comparison of (B) When only the sides of enamel rods are etched



**Fig. 39.2:** Various designs of the margins of tooth preparation (T) and cast restorations (R) (A) Shoulder with bevel, (B) Sloped shoulder, (C) Flat shoulder, (D) Chamfer, (E) Bevel, (F) Chisel edge, (G) Feather edge (Refer Table 39.1)

## VARIOUS DESIGNS OF OCCLUSAL AND GINGIVAL BEVELS

- Ultrashort or partial bevel:** The ultrashort or partial bevel is beveling of less than two-third of the total enamel thickness (Fig. 39.3 subfigure(A) at margin designated as 'a'. It is usually used to trim the enamel rods from cavity margins. It is used in type I casting alloys.
- Short bevel:** The short bevel is beveling of full thickness of enamel wall but not dentin [Fig. 39.3(B)b]. It is used mostly for restorations with type I and II casting alloys.
- Long bevel:** The long bevel includes full thickness of enamel and half or less than half thickness of dentin [Fig. 39.3(C)c]. Its main advantage is that it preserves the internal 'boxed up' resistance and retention features of the preparations. The bevel is mostly used in first three types (types I, II and III) of cast gold alloys.
- Full bevel:** Full bevel includes full enamel and dentinal wall [Fig. 39.3(D)d]. Its main disadvantage is that it deprives the preparation of its internal resistance and retention hence the chances of dislodgement of the restoration are more. Therefore, full bevel should be avoided except in cases where it is a must.
- Hollow ground (concave) bevel:** Hollow ground is concave in shape and not a bevel in true sense [Fig. 39.3(E)e]. All the above described bevels can be prepared in concave form to increase the resistance and retention of the cast restoration for class IV cast alloys. The concave bevel is rarely used.
- Counter bevel:** This type of bevel is used when capping of the cusps to protect and support them is done.

- Reverse or inverted bevel in anterior teeth:** It is beveling in the reverse or inverted shape given on the gingival seat in the axial wall toward the root in anterior teeth. In anterior teeth it is indicated in metal ceramics on the labial shoulder [Fig. 39.3(F)g] to increase the retention.
- Reverse or inverted bevel in posterior teeth:** In posterior teeth in MOD preparations for full cast metal restorations, it is used to prevent tipping of cast restoration in the directions shown with the arrows and to increase the resistance and retention [Fig. 39.3(G)h].
- Two to three degree undercut in dentin is given as indicated for amalgam restoration [Fig. 39.3(A)i].

## Flares

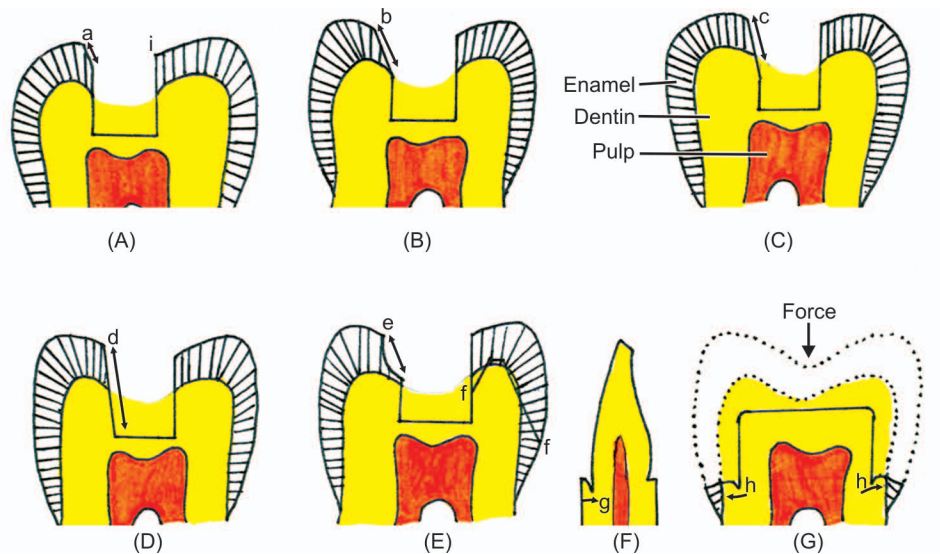
In intracoronal cavity preparation for castings, in the proximal box the facial and lingual wall flares are given. These flares are of two types.

### Primary Flare

Primary flares always have 45 degree angle with inner dentinal wall proper on the facial and lingual proximal walls. It is very much like long bevel formed of the enamel and part of dentin. It is prepared on the enamel and dentin (Fig. 39.4).

## Functions and Indications

These flares bring the facial and lingual proximal margins of the preparation to finishable and self-



**Fig. 39.3:** Various designs of occlusal and gingival bevels

| Shown in subfigure | Shown by alphabet |                                                                                                                         |
|--------------------|-------------------|-------------------------------------------------------------------------------------------------------------------------|
| (A)                | a.                | Partial or ultrashort bevel                                                                                             |
| (B)                | b.                | Short bevel                                                                                                             |
| (C)                | c.                | Long bevel                                                                                                              |
| (D)                | d.                | Full bevel—2 to 5 degree indicated for gold inlay                                                                       |
| (E)                | e.                | Hollow ground (concave) bevel                                                                                           |
| (E)                | f.                | Counter bevel                                                                                                           |
| (F)                | g.                | Reverse or inverted bevel in anterior teeth (given on labial side on metal ceramic crown preparation on anterior teeth) |
| (G)                | h.                | Reverse or inverted bevel in posterior teeth (in MOD cast metal inlay)                                                  |
| (A)                | i.                | 2 to 3 degree undercut in dentin as indicated for amalgam restorations                                                  |

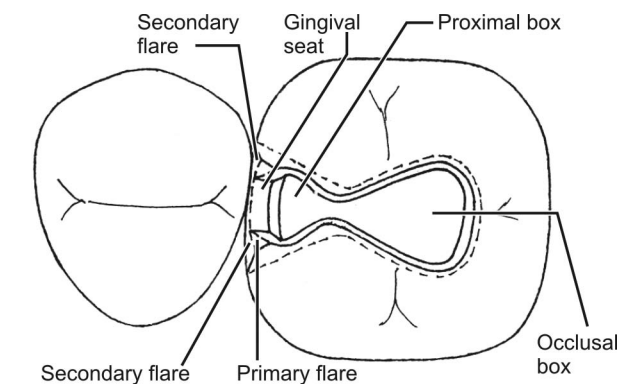
cleansable areas. These flares are indicated for all facial and lingual proximal walls of all intracoronal preparations. Flares also function as bevels.

### The Secondary Flare

The secondary flare is almost a flat plane peripherally superimposed on the primary flare. Mostly it is prepared only on the enamel but occasionally it may involve some dentin in all or parts of its surfaces. Unlike primary flares (which have 45 degree angle with dentin) secondary flares may have variable angulation, involvement and extent, depending on their function (Fig. 39.4).

### Functions and Indications

Flares perform all functions of bevels. In very widely buccolingually extended lesion, the remaining buccal



**Fig. 39.4:** Primary flare and secondary flare in class II mesio-occlusal inlay cavity preparation

and lingual tooth structure is usually too much thinned. The primary flare end in acute-angled marginal tooth

**Table 39.1:** Names and designs of margins of tooth preparations and cast restorations with their advantages, disadvantages and indications

| S. No. | Names and designs of margins | Shown in Fig. 39.2 at subfigure designated | Advantages                                                                                                                               | Disadvantages                                                                                                       | Indications                                                                                                 |
|--------|------------------------------|--------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|
| 1.     | Shoulder with bevel          | (A)                                        | Good edge strength due to more bulk of material along with the advantages of bevel                                                       | Involves excessive tooth cutting also in apical direction                                                           | Facial margin of posterior metal ceramic crowns having supragingival margins                                |
| 2.     | Sloped shoulder              | (B)                                        | Good edge strength due to more bulk with the advantages of bevel                                                                         | Involves excessive tooth cutting                                                                                    | Facial margin of all metal ceramic crowns. Commonly used                                                    |
| 3.     | Flat shoulder                | (C)                                        | Good edge strength due to more bulk                                                                                                      | More tooth cutting is required                                                                                      | Facial margin of metal ceramic and composite ceramic crowns. Commonly used.                                 |
| 4.     | Chamfer                      | (D)                                        | a. Easier to control extension and clear cut margins with sufficient bulk.<br>b. Metallic margins can be easily finished and polished.   | a. Chances of unsupported enamel rods are more.<br>b. Very careful removal of unsupported enamel rods is essential. | All margins of cast metal restorations and nonvisible margins of metal ceramic restorations. Commonly used. |
| 5.     | Bevel                        | (E)                                        | a. Less cutting of enamel is required.<br>b. Unsupported enamel rods are removed<br>c. Metal margins can be easily finished and polished | Apical margins have to be extended into gingival sulcus.                                                            | Margins of types I, II and III gold casting alloy restorations.                                             |
| 6.     | Chisel edge                  | (F)                                        | Much less cutting of enamel is required                                                                                                  | Indefinite and difficult to control location of the margins                                                         | a. Suitable on malposed and tilted teeth.<br>b. Rarely used.                                                |
| 7.     | Feather edge                 | (G)                                        | Least cutting of enamel is required                                                                                                      | a. Poor strength as inadequate bulk is provided.<br>b. Difficult to control and finish the margins                  | Its use must be avoided.                                                                                    |

structure, usually with unsupported enamel. A secondary flare superimposed at the correct angulation creates the required obtuse angulation of the tooth structure. During secondary flare preparation resistance and retention is not sacrificed, because the proper wall and primary flare are maintained at their proper location and angulation (45 degree).

## OVoid SHAPED TEETH

In ovoid shaped teeth usually marginal occluso-gingival undercuts are present on the facial and/or lingual peripheries of the cavity preparation. Attempt to

eliminate these undercuts will involve removal of excessive tooth structure resulting into weakening the same. Usually, a secondary flare superimposed on a primary flare in the proper angulation and extension can eliminate these undercuts with least sacrifice of the healthy tooth structure. In secondary flare surface defects or decalcifications can also be involved and removed.

## SLICE PREPARATION

Slice preparation is indicated in teeth with tapering or ovoid form. The slice preparation constitutes the conservative diskling of the proximal surface so as to



establish the buccal and lingual extent of the finish lines and provide a lap joint for finishing. These slices are also independently placed on buccal and lingual surfaces. The slice cutting is extended to the cervical floor or slightly occlusal to the cervical floor so as to preserve the maximum of the healthy tooth tissue. The cervical extension depends on the tooth form keeping in mind maximum conservation of the tooth tissue. Slice preparation assures sound enamel margin along with the margin of the casting which is easily adopted, finished and polished (see Fig. 29.4).

### AUXILIARY SLICE PREPARATION

Auxiliary slice preparation provides external support to weakened tooth areas which are subjected to heavy functional forces. This additional external support is provided by auxiliary slice preparation by partially wrapping around the proximal line angles. Auxiliary slice preparation with minimal removal of tooth tissue increases resistance form and reduces the chances of the tooth fracture. Retention form can also be obtained by auxiliary slice preparation (Fig. 29.4).

In inlay preparation an auxiliary slice preparation around buccal cusp will prevent lingual displacement of the inlay and vice versa, i.e. auxiliary slice preparation

around lingual cusp will prevent buccal displacement of the inlay.

### Modified Flare Preparation

Modified flare preparation is a combination of box and slice preparations. Initially the buccal and lingual proximal walls are prepared with minimum extension. Then proximal surface is slightly disked so as not to reduce the retention of buccal and lingual walls. Too much diskling of these walls should be avoided otherwise it will reduce the retention of the restoration (Fig. 29.5).

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# *Index*

## **A**

A new concept of operative approach 2  
Abfraction 360  
Abfraction lesion (idiopathic erosion) 306  
Abrasion 49, 305, 359  
Abrasion resistance 109  
Absorption 63  
Acid-etching technic 220  
Actinomyces viscosus 31  
Acute dental caries 37  
Adaptability 109  
Adhesion 207  
2 adhesive (3m ESPE) 228  
Aluminium bands or stainless steel bands 140  
Aluminium foil 140  
Aluminium foil incisal corner matrix 145  
Aluminium or copper collars 140  
Aluminium shell crowns 217  
Amalgam 100  
Amalgam blues 50  
Amalgam bonding systems 104, 190  
Amalgam restoration repairing 189  
Amalgampins 94  
Analgesia 156  
Anatomic matrices 140  
Anatomical matrix band 140, 143  
Anesthetic testing 51  
Annealing 329  
Anterior tooth guidance 21  
Antibacterial composites 242  
Antiseptics 152  
Asepsis 152  
Atomic force microscopes (AFM) 213  
Atraumatic restorative treatment (ART) 96, 270  
Attrition 49, 358  
Auscultation 47  
Automatrix 191  
Auxiliary slice preparation 287, 382  
Avulsed teeth 346

## **B**

Base metal alloys 282  
    crown 284  
    inlay 284  
    onlay 284  
    partial crown 284  
Bases 174

Beveled conventional cavity 238  
Beveled conventional class-V 308  
Beveled conventional design 256  
Beveled conventional design preparation 256  
Bevels 286, 378  
Biological evaluation 336  
Bite test 51  
Black's instrument formula 123  
    angle former 124  
    chisels 124  
    cleoid and discoid 125  
    gingival marginal trimmer 125  
    hatchet 124  
    hoe 124  
    knives 125  
    spoon excavator 125  
Blade or nib 123  
Bleaching 372  
Bleaching of non-vital (root filled) tooth 373  
Bleaching of vital tooth 373  
Body of lesion 34  
Bonded alumina crown 356  
Bonded amalgams 96  
Bonding agents 220  
Bonding interface 191  
Bonnet 280  
Box preparation 287  
Bruxism 24  
Bruxomania 24  
Buffing 211  
Burnishing 187, 211

## **C**

C factor 234  
CAD/CAM 277  
Calcium hydroxide 163  
Caries activity tests 42  
Cast coping 280  
Castable ceramic veneers 320  
Castable glass (dicor) 276  
Castable glass ceramic (dicor) 277  
Cavity liner 174  
Cavity liner suspensions 103  
Cavity liners 103, 163  
Cavity varnish 163  
Cellulose acetate and polycarbonate crown forms 217  
Cellulose wafer 118  
Cement - apatite interface  
    bilayered 229  
    sandwich technique 229

Cementation 300  
Centric occlusion 20  
Centric relation 20  
Ceramic inlays and onlays 273  
Cerec® system - CAD 277  
Cerestore crown 356  
Chamfer 378  
Chelators 223  
Chemical bonding 281  
Chisel edge 378  
Chlorhexidine 242  
Citric acid 220  
Class I cavity 74  
Class II cavity 76  
Class II inlay 284  
Class II onlay 284  
Class III cavities 80  
Class IV cavities 82  
Class V cavity 83  
Class VI cavities 84  
Class VII cavities 84  
Classification of amalgam 171  
Clearfil 224  
Clearfil new bond 226  
Clearfil se bond 228  
Coefficient of thermal expansion (CTE) 206  
Cohesion 329  
COL 165  
Cold sterilization 151  
Color 313  
Compaction 329  
Compound supported metal matrix 239  
Conditioners 220  
Conditioning 222  
Condyle 365  
Confocal laser scanning microscopy (CLSM) 42  
Contraindications of composites 236  
Convenience form 173  
Conventional cavity 237  
Conventional class V 308  
Conventional composite resins 235  
Conventional design preparation 256  
Conventional GIC 265  
Copper 140  
Cosmetic contouring 311  
Cotton rolls 118  
Counter bevel 379  
Covalent chemical bonds 229  
Coves 94

## 422 Textbook of Operative Dentistry

Crab-claw separator 147  
Craniomandibular joint 365  
Crazing 337  
Cross infection 151  
Crown forms 217  
CT scan (computer tomography scan) 51  
Custom made plastic matrix 140

### D

Dark zone 34  
DBA 224  
    self-etching primers 226  
Dead tracts 13  
Debonding 190  
Decomposed dentin 3  
Deflection 63  
Degassing 329  
Dental caries 29  
Dentatus Nystrom separator 147  
Dentin adhesions 222  
Dentin bonding agents 104, 224, 239  
    generations 224  
    gun 240  
Dentinal sclerosis 36  
Dentinoenamel junction 12  
Dentinogenesis imperfecta 362  
Dentinometer 54  
Dentinometer/prepometer 6  
Dentist-prescribed home-applied' technique 374  
Diagnodent 41  
Diagnostic aids 47  
Die materials 297  
Digital imaging 40  
Digital imaging FOTI 39  
Direct pulp capping 14  
Direct veneering procedure 316  
Direct wax pattern 298  
Directly bonded composite restorations 245  
Disclusion 367  
Discolorations 361  
Disinfectants 152  
Disinfection 152  
Ditching 50  
DNA chip technology (DNACT) 42  
Dr GV Black 1  
Dye enhanced laser fluorescence (DELF) 41  
Dyes 39  
Dyract 309

### E

Eburnated dentin 13  
Electraloy 328  
Electrosurgery 166

Elliot wedge or separator 147  
Ellis classification 362  
Enamel bonding agents 239  
Enamel rods 11  
Enameloplasty 90, 176  
Endon frame 114  
Endoscope technique 40  
Epithelial attachment 165  
Erosion 49, 305, 359  
Esthetic procedures 311  
Etchants 220  
Etched porcelain veneers 319  
Ethylene diamino tetra acetic acid (EDTA) 223  
Exploration 48  
Extrinsic staining 370

### F

Feather edge 378  
Federation dentaire internationale (FDI) 10  
Feldspathic porcelain jacket crown 356  
Ferrier design 332  
Ferrier single or double bow separator 147  
Ferrule feature 350  
Fiber optic transillumination (FOTI) 39  
Finish of the enamel walls and margins 173  
Finishing 211  
Finishing burs 211  
Flat shoulder 378  
Flowable composites 236  
Fracture line 50  
Freeway space 21  
Full bevel 379  
Full circle or ring bands 144  
Full jacket crown 355

### G

Gallium 196  
Gallium amalgam 208  
Gingivoplasty 166  
Glass ionomer cement 164  
Glazing 240  
Gluma  
    hybrid layer 226  
    hybridization 226  
Gold dent 329  
Gold foil 328  
Golden proportion 312  
Grooves 93

### H

Hand instruments 119  
Heat treatment 121

Hema (2-hydroxyethyl methacrylate) 224  
Hollow ground (concave) bevel 379  
Hue 65  
Hybrid composite resins 235  
Hybrid resin 266  
    abfraction 270  
    abrasion and erosion 270  
    debridement, prophylaxis, isolation 268  
    sandwich (double or bilayered) restorations 270  
Hybridoid regions 229  
Hydrofluoric acid 229  
Hypnosis 156

### I

Illusion of shape or form 311  
In office bleaching 373  
Indirect method wax pattern 298  
Indirect pulp capping 14, 161  
Indirect veneer technique 317  
Infection 152  
Injection molded core materials 277  
Inlay taper 285  
Instrument tray 61  
Instruments grasps 126  
Interim restorations 166, 216  
Intermediary base 175  
Internal boxes 94  
Intrinsic staining 370  
Inverted pen grasp 127  
Irreversible pulpitis  
    acute apical periodontitis 345  
    high filling or restoration 345  
    tooth hypersensitivity 345  
Ivory adjustable separator 147  
Ivory matrix retainer number 1 140  
Ivory matrix retainer number 8 140

### L

Lactobacilli 32  
Laminate veneers 311  
Laminates 354  
Laser curing 240  
Laser Doppler flowmetry 51  
Laser for caries removal and tooth preparation 136  
Lasers 5, 136  
Lateral guidance 21  
Lateral tubule hybridization 223  
Leucite reinforced porcelain 277  
Light cured glass ionomer cements 266  
Line angle 72  
Lip-extractors 119  
Loma linda design 334  
Long bevel 379

**M**

Magnesia core porcelain 276  
 Malacotic 35  
 Maleic acid 220  
 Maleic acid (scotch bond) 223  
 Malformations 361  
 Mantle dentin 13  
 Marginal gap 50  
 Mat foil 328  
 Mat gold 328  
 Matrices 183  
 Matrix band 139  
 Mercury alloy ratio 195  
 Mercury hygiene 190  
 Mesial half crown 354  
 4 META system 191  
 Methyloxy ethyl trimellitic anhydride (META) 190  
 Microabrasion 371  
 Microfilled resins 235  
 Microleakage 207  
 Micromechanical bonding 280  
 Microorganisms 31  
 Microtags 221  
 Midline diastema 314  
 Mineral trioxide aggregate (MTA) 163  
 MOD cavity preparation 180  
 Modified (conservative) cavity 238  
 Modified (conservative) class V 308  
 Modified (conservative) preparation design 256  
 Modified cavity design 256  
     conservative composite restoration 260  
     preventive resin restorations 260  
 Modified flare preparation 287  
     collar 294  
     gingival bevels 287  
     skirt 294  
     slot 294  
 Modified palm and thumb grasp 128  
     high speeds 131  
     low or slow speed 131  
     medium speeds 131  
     super ultra high speed 131  
     ultra high speed 131  
     ultra low speed 131  
 Modified pen grasp 126  
 Munsell color system 65  
     buccal 70  
     distal 70  
     labial 70  
     lingual/palatal 70  
     mesial 70  
 Mylar strip matrix 239  
 Mylar strips 140, 144

**N**

New mobility index (NMI) 52  
 Nightguard vital bleaching 374  
 Non interfering true separator 147  
 Nosocomial infection 152  
 Nystrom's matrix band retainer 143  
 Nystrom's retainer 140

**O**

Occlu print 261  
 Occlusal film 54  
 Odontalgia 345  
 Onlays 352  
 Opacity 63  
 Operating stools 60  
 Operative dentistry 1  
 Optibond solo 226  
 Optic bond solo plus (3m ESPE) 228  
 Oral thermal cycle 108  
 Orthopantograph 54  
 Outline form 172  
 Ozone 6

**P**

P [2-methacryloxy ethyl phenyl hydrogen phosphate] 224  
 Packable condensable composites 236  
 Packable posterior composites 243  
 Palm and thumb grasp 128  
 Palmer system 9  
 Palodent bitine springy ring wedge 149  
 Parr's universal separator 147  
 Partial jacket crowns 354  
 Percussion 47  
 Perry separator 147  
 Phosphoric acid 220  
 Piggy-back wedging 148  
 Pins 94  
 Pit and fissure sealant 105  
 Plastic matrices 140  
 Plastic matrix strips 140, 144  
 Plastic strips 140, 144  
 Platinized gold foil 328  
 Point angle 72  
 Polishing 211  
 Polycarboxylate cement 164  
 Polymerization shrinkage 110, 207, 234  
 Post and core 350  
 Post restorative pain 195  
 Powdered gold 329  
 Power bleaching 373  
 PQ 1 (ultradent) 228  
 Precautions for use of laser 138

Pre-fabricated dowels 350  
 Prefabricated matrices 145  
 Pre-heating procedure 275  
     glazing and shading 276  
 Prepometer 54  
 Prevention and control of caries 43  
 Primary flare 379  
 Prime and bond 226  
 Primers 220  
 Profilometers 213  
 Prompt-1-pop 228  
 Proprioceptive terminals 366  
 Protective eye wear 152  
 Protective restorations 217  
 Proteolysis-chelation theory 31  
 Proteolytic theory 31  
 Proximal overhangs 50  
 Proximal surface caries 49

**Q**

Quadrant dentistry 189

**R**

Rampant caries  
     adolescent rampant caries 37  
     nursing bottle rampant caries 37  
     xerostomia 37  
 Reflection 63  
 Refraction 63  
 Reparative dentin 13  
 Resistance form 173  
 Restoration 96  
 Restorative GIC 265  
 Retainerless automatrix 140  
 Retainerless automatrix band 143  
 Retainerless matrix band 143  
 Retainerless walser filling matrix 140, 150  
 Retention form 173  
 Retentive pins 199  
     cemented pins 201  
     friction-locked pins 201  
     self-threading pin 201  
 Reverse curve 172, 177  
 Reverse or inverted bevel 379  
 Reverse three quarter crown 354  
 Royal mineral succedaneum 1, 171  
 Rubber dam 112, 118  
 Rubber dam clamp forceps 15  
 Rubber dam sheet 115  
 RVG 52

**S**

*S. mutans* 32  
 Sand blasted (alumina) 229



## 424 Textbook of Operative Dentistry

Sclerotic dentin 13  
Scotchbond 226  
Sealed amalgam restorations 208  
Secondary dentin 13  
Secondary flare 380  
Self-curing composites 240  
Sepsis 152  
Seven-eighth crown 354  
Short bevel 379  
Shoulder with bevel 378  
Silane coupling agent 229  
Single bond (3m ESPE) 228  
Single bond (3m) 228  
Skirts 94  
Slice preparation 287, 381  
Sloped shoulder 378  
Slots 94, 177  
Smear layer 160, 206  
Smooth surface caries 33  
Soft teeth 35  
Splinting 340  
'S' shaped matrix band 140, 144  
Stainless steel readymade crowns 217  
Stamp cusps 27  
Steele's Siqveland self-adjusting matrix retainer 140  
Steele's Siqveland self-adjusting matrix holder for tapering teeth 142  
Sterilization 152  
Stomatognathic system 365  
*Streptococcus mutans* 31  
Study casts 52  
Substrate 230  
Subtraction radiography 41  
Sub-transparent dentin 35  
Suction devices 112  
Supporting cusps 27  
Surface texture 312  
Surface zone 34  
Syringe 240

### T

Tactile method 40  
Temporization 219  
Temporomandibular joint 18  
Test cavity 51  
Thermal conditioning  
    hybrid layer 223  
    resin reinforced layer 223  
Thermal cycling 174  
Three quarter crown 354  
Tofflemire matrix retainer 140  
Tofflemire universal matrix band retainer 141  
Tooth flexure 230  
Tooth numbering 9  
Traction principle 146  
Translucency 63, 313  
Translucent zone 34  
Transmission 63  
Transparency 63  
Transparent crown form 140  
Transparent crown form matrices 145  
    aluminium or copper collars for non-light  
    cured tooth colored restorations 146  
    anatomic matrix for light and non-light  
    cured, direct tooth-colored materials  
    146  
    prefabricated plastic matrices 146  
Transparent plastic crown forms 140  
Transparent plastic partial crown forms 140  
Traumatic injury 346  
Traumatized teeth 362  
'T' shaped matrix band 140, 143  
Tunnel cavity preparation 96  
Turbid dentin 36  
Two-digit system 10

### U

Ultra short or partial bevel 379  
Universal system of tooth numbering 9

### V

Vacuum-formed plastic template [omnivac] technique 217  
Vanadium 32  
Vanguard electronic caries detector 41  
Varnish 174  
Veneers 315  
    full veneers 316  
    partial veneers 316  
Vitality 53  
Voids 50

### W

Walking bleach technique for root filled teeth 373  
Wedge principle 146  
Wedges 148, 183  
Wedjets 117  
Wood ward separator 147

### X

Xeroradiography 40

### Y

Young frame 114

### Z

Zinc oxide-eugenol 163  
Zinc phosphate cement 163  
Zinc silico-phosphate cements 105  
Zsigmondy system 9

# Multiple Choice Questions

1. The oldest and most widely used method of tooth nomenclature is:
  - A. Universal system
  - B. FDI system
  - C. Two digit system
  - D. Palmer system
2. The system to designate a tooth which is simple to understand and to teach as well as readily communicable in print and by wire is:
  - A. Zsigmondy system
  - B. Universal system
  - C. FDI/ Two digit system
  - D. None of the above
3. In a system, a tooth is designated number '46', the tooth is:
  - A. Permanent maxillary right first molar
  - B. Permanent maxillary right 2nd molar
  - C. Permanent mandibular right first molar
  - D. Permanent mandibular left first molar
4. A mesial proximal carious lesion of the mandibular right 1st molar is indicated by:
  - A. 46<sup>1</sup>
  - B. 46<sup>2</sup>
  - C. 46<sup>3</sup>
  - D. 46<sup>4</sup>
5. "Double inverted cone" type of penetration of dental caries is seen in:
  - A. Smooth surface caries
  - B. Pit and fissure caries
  - C. Both of the above
  - D. None of the above
6. Pit and fissure lesions are represented by:
  - A. Apex of cone facing each other
  - B. Base of cone facing each other
  - C. Double inverted cone
  - D. None of the above
7. GV Black simply classified cavities as:
  - A. Two classes of smooth surface and three classes of pit and fissure lesions
  - B. Three classes of smooth surface and two classes of pit and fissure lesions
  - C. One class of pit and fissure and four classes of smooth surface lesions
  - D. None of the above
8. Cavities that occur exclusively in posterior teeth are:
  - A. Class 1 cavities
  - B. Class 5 cavities
  - C. Class 2 cavities
  - D. Class 4 cavities
9. The class(es) of cavity which occurs both in anterior and posterior teeth is/are:
  - A. Class 3
  - B. Class 2
  - C. Class 1 and 6
  - D. Class 4
10. Removal of deep, pulp encroaching caries should be made using:
  - A. High rotational speeds
  - B. Low rotational speeds
  - C. Very high rotational speeds
  - D. All of the above
11. Pulpal damage can result from:
  - A. Lack of coolant
  - B. Excessive hand pressure
  - C. Dull instrument
  - D. All of the above
12. Number of point angles in 'class 3' cavity preparation is:
  - A. 4
  - B. 5
  - C. 3
  - D. 11

## 384 Textbook of Operative Dentistry

13. **Diagnosis of cracked tooth syndrome is made by:**
  - A. Biting on solid object and release of pressure
  - B. Only during bites
  - C. Percussion
  - D. All of the above
14. **Most commonly fractured cusp is:**
  - A. Buccal cusps of maxillary molars
  - B. Buccal cusps of mandibular molars
  - C. Lingual cusps of maxillary molars
  - D. Lingual cusps of mandibular molars
15. **Teeth most commonly congenitally absent are:**
  - A. Mandibular 2nd bicuspid
  - B. Maxillary lateral incisors
  - C. Mandibular 1st bicuspid
  - D. Mandibular primary 2nd molar
16. **Radiolucent material among the following is:**
  - A. Amalgam
  - B. Glass ionomer
  - C. Some composite resin
  - D. Calcium hydroxide
17. **Proximal carious lesion occurs mostly:**
  - A. Just occlusal to contact area
  - B. Just cervical to contact area
  - C. Irrespective of contact area
  - D. None of the above
18. **Complete mouth examination requires how many radiographs?**
  - A. 6 bitewing and 14 periapical films
  - B. 4 bitewing and 12 periapical films
  - C. 4 bitewing and 18 periapical films
  - D. 6 bitewing and 12 periapical films
19. **Posterior bitewing radiographs are needed to show:**
  - A. Virgin or secondary interproximal carious lesion
  - B. Contour of restoration
  - C. Pulp size and calcification
  - D. All of the above
20. **In panoramic radiography, there is usually overlapping in:**
  - A. Molar region
  - B. Incisor region
  - C. Bicuspid area
  - D. None of the above
21. **All of the following are true regarding panoramic radiographs except:**
  - A. Gag-reflex problems are eliminated
  - B. Relative positions of teeth are clear
  - C. There is no overlapping in bicuspid area
  - D. There is minimal distortion
22. **Development of smooth surface dental caries is due to all of the following except:**
  - A. Low salivary flow
  - B. Frequent sucrose consumption
  - C. Radiation therapy
  - D. Amount of sucrose consumption
23. **Smooth surface caries is mainly caused by:**
  - A. Lactobacilli
  - B. Streptococcus mutans
  - C. Actinomyces
  - D. All of the above
24. **The purposes of cavity preparation is/are:**
  - A. Removal of all the defects of enamel, dentin and cementum
  - B. To locate the margins of restoration as conservatively as possible
  - C. To allow for esthetic and functional placement of restorative material
  - D. All of the above
25. **Patients with which of the following minimum salivary levels of Streptococcus mutans are considered as high risk for dental caries:**
  - A. Above  $10^4$  CFU/ml
  - B. Above  $10^6$  CFU/ml
  - C. Above  $10^8$  CFU/ml
  - D. Below  $10^4$  CFU/ml
26. **A patient with less than  $10^4$  CFU of lactobacilli per ml of saliva is associated with:**
  - A. High caries risk group
  - B. Medium caries risk group
  - C. Low caries risk group
  - D. None of the above

- 27. According to Klock and Krasse, the high caries risk group comprised of:**
- 25% of population
  - 23% of population
  - 28% of population
  - 32% of population
- 28. The first anti-gingivitis oral rinse approved by FDA and ADA council is:**
- 2% chlorhexidine gluconate
  - 0.2% chlorhexidine gluconate
  - 0.12% chlorhexidine gluconate
  - 1% chlorhexidine gluconate
- 29. The method of choice for removal of interproximal plaque is:**
- Unitufted waxed floss
  - Multitufted unwaxed floss
  - Multitufted waxed floss
  - Unitufted unwaxed floss
- 30. Sealants are not recommended routinely on:**
- Primary molars
  - Over another restorative material
  - Interproximal lesions
  - Carious pit or fissure
  - All of the above
- 31. Percentage of pit and fissure caries in children is:**
- 60 to 70 %
  - 50 to 60 %
  - 80 to 90 %
  - 40 to 60 %
- 32. Incidence of dental caries in young children is most effectively reduced by:**
- Sealants
  - Oral prophylaxis
  - Flossing
  - None of the above
- 33. Dental equipment refers to all of the following except:**
- Dental chair
  - X-ray units
  - Operating unit
  - Excavators
- 34. The position or manner of use of an instrument is described by:**
- Class
  - Subclass
  - Suborder
  - Order
- 35. Basic instrument formula consists of:**
- Four digits/units
  - Three digits/units
  - Five units digits/unit
  - All of the above digits/unit
- 36. In a three unit formula, the second unit denotes:**
- Blade width in mm
  - Blade width in cm
  - Blade length in mm
  - Blade angle in centigrade
- 37. The first unit of basic instrument formula denotes:**
- Blade width in mm
  - Blade width in 1/10 mm
  - Blade length in 1/10 mm
  - Blade length in mm
- 38. The fourth unit added to the basic three unit instrument formula placed at 2nd position denotes:**
- Blade length in mm
  - Blade angle in centigrade
  - Angle formed between cutting edge and central axis of the shaft
  - Width of blade in 1/10 mm
- 39. In general sense, all the hand cutting instruments are:**
- Hatchet
  - Chisels
  - Excavators
  - None of the above
- 40. The spoon excavator is:**
- Chisel
  - Modified hatchet
  - Modified chisel
  - Hatchet
- 41. Frequently used instruments for placing retentive grooves for amalgam and composite resins are:**
- Small round burs nos.  $\frac{1}{4}$  to  $\frac{1}{2}$
  - Small inverted cone bur
  - Small chisels
  - Round bur nos. 2 and 4



## 386 Textbook of Operative Dentistry

42. Rotary cutting instruments should be applied for caries removal and cavity preparation refinement in the range of:
  - A. Ultra high speed
  - B. Ultra speed
  - C. High speed
  - D. Conventional speed
43. Dr GV Black, father of operative dentistry had following qualification:
  - A. No professional qualification
  - B. Only honorary dental qualification
  - C. Only honorary medical qualification
  - D. Both honorary dental and honorary medical qualification
44. The most reliable sterilization device is:
  - A. Immersion in 100°C water for 30 minutes
  - B. Soaking in activated 2% alkaline glutaraldehyde for 10 minutes
  - C. Autoclave
  - D. Steam under pressure for 35 pounds for 15 minutes
45. Autoclave cycle is achieved with the steam under pressure of:
  - A. 15 pounds and 121°C for 15 minutes
  - B. 35 pounds and 258°F for 5 minutes
  - C. Both of the above
  - D. 25 pounds and 131°C for 10 minutes
46. Chemiclave is:
  - A. Steam pressure sterilization
  - B. Chemical vapor pressure sterilization
  - C. Drug heat sterilization
  - D. None of the above
47. Instruments that cannot withstand autoclaving may be sterilized effectively with:
  - A. 2 % glutaraldehyde
  - B. 1 % sodium hypochlorite
  - C. Ethylene oxide gas
  - D. 70% ethyl alcohol
48. Knoop hardness number of enamel is:
  - A. 241
  - B. 51
  - C. 68
  - D. 343
49. KHN of dentin and cementum are respectively:
  - A. 68 and 343
  - B. 68 and 40
  - C. 48 and 64
  - D. 58 and 30
50. In order to assume a sound enamel margin, the cavosurface angle of occlusal wall of Class 5 cavity should be:
  - A. 110°
  - B. 90°
  - C. 120-130°
  - D. 45°
51. Which of the following statement is true regarding acid etching *except*:
  - A. It is done with 37% or 50% phosphoric acid
  - B. It results in increased surface area
  - C. It provides higher surface energy
  - D. Etching for an additional period results in greater penetration of polymers
52. There is a complete remineralization of the acid-etched enamel after the acid treatment, if exposed to saliva within:
  - A. 30 days
  - B. 45 days
  - C. 60 days
  - D. 65 days
53. Which of the following is/are true regarding enamel?
  - A. It exhibits permeability
  - B. It is about 5 to 20 times more resistant to abrasion than dentin
  - C. It's KHN is 343
  - D. All of the above
54. The number of dentinal tubules ranges from:
  - A. 30,000 to 70,000/mm<sup>2</sup>
  - B. 20,000 to 60,000/mm<sup>2</sup>
  - C. 3500 to 7000/mm<sup>2</sup>
  - D. None of the above
55. All of the following statements are true *except*:
  - A. Class (type) C and Class (type) D deep cavities does not need liners
  - B. Calcium hydroxide serves the function of liner
  - C. Liners minimize or prevent microleakage
  - D. Liners provide thermal protection
56. Which of the following is contraindicated beneath composite resins as liner/ base?
  - A. Calcium hydroxide
  - B. Zinc oxide-eugenol
  - C. Glass ionomer
  - D. None of the above

- 57. Who was the first to describe that the mixture of oil of clove and zinc oxide forms a plastic mass and hardens?**  
 A. EJ Molnar                      B. JF Thomas  
 C. EC Chisolm                  D. JK Avery
- 58. Zinc oxide-eugenol liners are:**  
 A. Bacteriocidal  
 B. Bacteriostatic  
 C. Both of the above  
 D. None of the above
- 59. Which of the following are true about the effects of Eugenol on different cells?**  
 A. It is a competitive inhibitor of prostaglandin synthetase in  $10^{-5}$  to  $10^{-4}$  mol/l range  
 B. It is irreversibly neurotoxic above  $10^{-3}$  mol/L range  
 C. It is a reversible vasodilator in the  $10^{-4}$  to  $10^{-3}$  mol/L range  
 D. All of the above
- 60. All of the following are true regarding calcium hydroxide except:**  
 A. It is often selected as a main intermediary base  
 B. It can be used under composites  
 C. It does not resist acid-etching  
 D. It can be used in class (type) 'C' depth cavities
- 61. Which of the following cement bases has thermal conductivity similar to dentin?**  
 A. Polycarboxylate  
 B. Zinc phosphate  
 C. Glass ionomer  
 D. None of the above
- 62. Traditionally, zinc phosphate has been the cement base of choice due to:**  
 A. A high compressive strength  
 B. A thermal conductivity similar to dentin  
 C. Both of the above  
 D. None of the above
- 63. The greatest success in indirect pulp capping technique occurs in:**  
 A. Attrited teeth  
 B. Extensive carious teeth  
 C. Young patients  
 D. Young patient with diminished pulp vascularity
- 64. Which of the following are true about direct pulp capping?**  
 A. Mechanically exposed teeth have greater success rate than carious exposures  
 B. Final restorative materials do not affect success  
 C. Generally, individual teeth involved in a fixed prosthesis are candidates for direct pulp capping  
 D. All of the above
- 65. The success or failure of direct pulp capping depends on:**  
 A. Quality of blood flow  
 B. Amount of blood flow  
 C. History of previous pain  
 D. Age of the patient  
 E. All of the above
- 66. A technique which utilizes calcium hydroxide as liner placed on thin layer of questionable remaining dentin is termed as:**  
 A. Direct pulp capping  
 B. Indirect pulp capping  
 C. Vitality tests  
 D. Compaction technique
- 67. Which of the following is considered the most universal operating position for operator?**  
 A. 9 o'clock                      B. 7 o'clock  
 C. 11 o'clock                    D. 12 o'clock
- 68. A common fault in operating at 12 o'clock position is:**  
 A. Using direct vision  
 B. Bending of the back and neck of operator  
 C. Using indirect vision  
 D. Both A and B
- 69. The commonly used mouth mirror sizes are:**  
 A. No. 3 to No. 5  
 B. No. 1 to No. 2  
 C. No. 6 to No. 7  
 D. All of the above
- 70. Ideally, isolation of the operative field is accomplished by use of:**  
 A. Cotton rolls  
 B. Cotton roll holders  
 C. Rubber dam  
 D. Absorbent wafers

### 388 Textbook of Operative Dentistry

**71. A second choice of tooth isolation is by:**

- A. Cotton rolls      B. Cotton roll holders
- C. Absorbent wafers      D. All of the above

**72. Who was the originator of the rubber dam?**

- A. Dr SC Barnum      B. Dr MH Anderson
- C. Dr CR Bennet      D. Dr DC Smith

**73. Dental rubber dam is available in the width of:**

- A. 1 to 15 cm      B. 12.5 to 15 cm
- C. 15 to 20 cm      D. 17.5 and 22.5 cm

**74. Which of the following are advantages of dark shade rubber dam?**

- A. It provides good contrast with teeth
- B. It reduces light reflection
- C. Both of the above
- D. Advantages are same as light shade

**75. The six-inch width rubber dam is used with:**

- A. Young frame      B. Endon frame
- C. Elastic strap      D. Both B and C

**76. Which of the following frames permits the formation of a rubber dam pouch?**

- A. Young frame      B. Endon frame
- C. Both A and B      D. None of the above

**77. "Theta triangles" refer to:**

- A. Cotton rolls      B. Cotton roll holders
- C. Absorbent wafers      D. Rubber dam retainers

**78. The microhardness value of the reparative dentin is:**

- A. 61 KHN      B. 65 KHN
- C. 40 KHN      D. 30 KHN

**79. The cavity which is mechanically and biologically adequate along with maximum RDT is grouped as:**

- A. Class (type) B depth cavity
- B. Class (type) D depth cavity
- C. Class (type) A depth cavity
- D. Class (type) E depth cavity

**80. Which of the following is best barrier between a restorative material and the pulp?**

- A. Zinc phosphate
- B. Calcium hydroxide liner
- C. Sound dentin
- D. Varnish

**81. A material when applied to the prepared tooth surface, its solvent quickly evaporates leaving a thin film of resinous material, is:**

- A. A liner      B. Intermediary base
- C. Varnish      D. None of the above

**82. Cavity varnishes are film-forming solutions possessing:**

- A. Thermal insulating quality
- B. Semi-permeable quality
- C. Quality of not resisting microleakage
- D. All of the above

**83. All of the following are characteristics of calcium hydroxide *except*:**

- A. It acts as direct and indirect pulp capping agent
- B. It acts as a protective chemical barrier beneath filled and unfilled resins
- C. It acts as obtundent
- D. Its resinous solution acts as a cavity liner

**84. Which of the following cements form chemical bond with the tooth structure?**

- A. Zinc phosphate and glass ionomer
- B. Zinc polycarboxylate and ZnO-Eugenol
- C. Zinc polycarboxylate and Glass ionomer
- D. Zinc polycarboxylate and zinc phosphate

**85. The most effective and widely used acceptable mechanical gingival tissue management during operative procedures is:**

- A. A wood wedge
- B. Cotton rolls
- C. Fine cotton fibers with ZnO-eugenol type of cement
- D. All of the above

**86. Gingival retraction cords containing 0.5 mg racemic epinephrine and astringent are avoided in:**

- A. Hyperthyroidism      B. Hypertension
- C. Heart diseases      D. All of the above

**87. All of the following are the advantages of zinc oxide eugenol used as gingival tissue displacement *except*:**

- A. High quality of tissue tolerance
- B. Effectiveness of tissue eversion
- C. It promotes granulation
- D. Produces quick results

|      |      |      |      |      |      |      |      |      |
|------|------|------|------|------|------|------|------|------|
| 71 D | 72 A | 73 B | 74 C | 75 D | 76 B | 77 C | 78 C | 79 C |
| 80 C | 81 C | 82 B | 83 C | 84 C | 85 C | 86 D | 87 D |      |

- 88. The rapid and easy method of tooth separation is:**  
 A. Chemical separation  
 B. Mechanical separation  
 C. Grass line ligature thread  
 D. True separator
- 89. Elliot separator works on the principle of:**  
 A. Wedge                      B. Traction  
 C. Chemical                  D. None of the above
- 90. Which of the following is the double bow separator?**  
 A. Elliot separator    B. Swartz separator  
 C. Ferrier separator   D. Cox separator
- 91. Ferrier double bow separators work on the principle of:**  
 A. Wedge                      B. Pulley  
 C. Traction                    D. Chemical means
- 92. Which of the following is/are dentin desensitizing agent?**  
 A. Potassium salts  
 B. 33% sodium fluoride solution  
 C. Strontium salts  
 D. All of the above
- 93. Iontophoresis helps in:**  
 A. Reducing dentin sensitivity  
 B. Mineralization  
 C. Demineralization  
 D. Increasing permeability of dentin
- 94. Which of the following restorative material is most widely used inspite of certain drawbacks?**  
 A. Restorative resins    B. Direct filling gold  
 C. Dental amalgams    D. Unfilled resins
- 95. Which of the following ADA specification covers dental amalgam alloy:**  
 A. ADA specification No. 2  
 B. ADA specification No. 3  
 C. ADA specification No. 4  
 D. ADA specification No. 1
- 96. The low copper dental amalgam alloy contains maximum amount of copper upto:**  
 A. 3%                          B. 19%  
 C. 6%                          D. 11%
- 97. The weakest and most corrodible phase of dental amalgam is:**  
 A.  $\text{Ag}_2\text{Hg}_3$                       B.  $\text{Sn}_{7-8}\text{Hg}$   
 C.  $\text{CuSn}_6$                         D. None of the above
- 98. In high copper dental amalgam alloy, which phase either diminishes or is eliminated?**  
 A.  $\gamma$  phase                      B.  $\gamma_1$  phase  
 C.  $\gamma_2$  phase                      D. Matrix phase
- 99. All of the following are features of the high copper amalgam alloys except:**  
 A. Low dimensional changes  
 B. Low compressive strength  
 C. Lower creep values  
 D. Less susceptible to corrosion
- 100. From a clinical standpoint, the dental amalgam is:**  
 A. Soluble                      B. Partially soluble  
 C. Insoluble                    D. None of the above
- 101. The first "form" of the silver amalgam was advocated by:**  
 A. H Letzel in (1845) in New York  
 B. M Taveau in (1826) in Paris  
 C. GV Black in (1896) in Canada  
 D. WB Eames in (1850) in Sweden
- 102. Which material was advertised as the "Royal Mineral Succedaneum" by the CRAWCOUR brothers in United States ?**  
 A. Gold  
 B. Dental amalgam  
 C. Restorative resins  
 D. Porcelain
- 103. When a cavity is prepared for silver amalgam, the provision made to prevent displacement of filling is:**  
 A. Resistance form  
 B. Convenience form  
 C. Retention form  
 D. None of the above
- 104. Ideal relationship of the enamel wall and amalgam surface is:**  
 A. Acute angle                  B. Obtuse angle  
 C. Butt-type junction    D. None of the above



### 390 Textbook of Operative Dentistry

- 105. The outline form of class V amalgam cavity is dictated principally by:**
- Direction of enamel rods
  - Extension of caries process
  - Involved tooth
  - Marginal gingiva
- 106. In class V amalgam cavity the retention grooves are placed in the:**
- Mesial and distal wall
  - Dentin
  - Cervical and occlusal wall
  - Axial wall
- 107. When the pulpoaxial line angle in class II cavity preparation is not bevelled /rounded, stress is concentrated in:**
- Dentinal line angle
  - Amalgam surrounding line angle
  - Axial wall
  - Pulpal wall
- 108. Retention grooves for class II amalgam cavity are placed in dentin of:**
- Gingival wall
  - Buccal and lingual proximal wall
  - Axial wall
  - None of the above
- 109. A “chisel” is used to cleave away unsupported proximal enamel and to plane and finish proximal enamel walls with:**
- Pen grasp
  - Modified pen grasp
  - Palm and thumb grasp
  - Reverse pen grasp
- 110. All of the following are true about “matrix band” except:**
- It is used when two or more surfaces are involved
  - It provides general contour of the restoration
  - It does not substitute for the lost wall of the tooth
  - Both carbon and stainless steel bands are available
- 111. Most often used thickness of the matrix band is:**
- 0.0015 cm
  - 0.0015 inch
  - 0.015 inch
  - 0.0028 mm
  - 0.0015 mm
- 112. In a patient, MO cavity is prepared on the mandibular first molar, the position of the matrix band is:**
- At the level of proposed marginal ridge
  - Slightly above the level of proposed marginal ridge
  - Approximately 2 mm above the proposed marginal ridge
  - Slightly below the proposed marginal ridge
- 113. Which of the following ADA specifications defines the purity of dental mercury?**
- ADA specification no.1
  - ADA specification no. 2
  - ADA specification no. 3
  - ADA specification no. 6
- 114. The triturated mass of amalgam is further worked to enhance the uniformity and plasticity of the mass, the process is called as:**
- Amalgamation
  - Condensation
  - Mulling
  - None of the above
- 115. The most predominant and strongest phase of the amalgam mass is:**
- Gamma 2
  - Gamma 1
  - Gamma
  - Voids
- 116. When the diameter of the condenser point reduces to half, the force delivered would be same when applied load is:**
- Half the original force
  - Double the original force
  - Increased four times the original force
  - Approximately one fourth of original force
- 117. TYTIN is a:**
- Slow reacting dental amalgam alloy
  - Rapid reacting dental amalgam alloy
  - A Nitinol wire
  - Pure titanium
- 118. According to the survey (1985) of most dentists of Canada and USA, the principal reason behind replacing a restoration was:**
- Primary caries
  - Secondary caries
  - Poor cavosurface margins
  - Marginal deterioration

- 119. Finishing and polishing of amalgam restorations are completed by:**  
 A. Iron oxide                      B. Aluminum oxide  
 C. Tin oxide slurry              D. Pumice
- 120. "Rhein trimmers" are instruments which accomplish:**  
 A. Round axiopulpal line angle  
 B. Removes bulky overhangs of amalgam restoration  
 C. Same as gingival margin trimmer  
 D. Removal of discrepancies existing in gingival area
- 121. The first translucent filling material produced by Fletcher was:**  
 A. Glass ionomer cement  
 B. Silicate cement  
 C. Composite resin  
 D. 'Hybrid' filled resin
- 122. After setting, the silicate surface exhibits severe crazing and increase in solubility and opacity due to:**  
 A. Increased temperature  
 B. Covering with grease  
 C. Early moisture contamination  
 D. Dehydration
- 123. The major clinical problem/s associated with the silicate cement is/are:**  
 A. Decreased working time  
 B. High solubility and disintegration in oral fluid  
 C. Short clinical life in less hygienic area  
 D. Both B and C
- 124. Which of the following is/ are the drawback/s of the tooth colored resin material developed in 1930 in Germany?**  
 A. It lacks color stability  
 B. High degree of polymerization shrinkage  
 C. High coefficient of thermal expansion  
 D. All of the above
- 125. The basic "polymer" of the composite resin system was developed by:**  
 A. Dr Ray Bowen  
 B. Dr MG Buonocore  
 C. Dr RG Craig  
 D. Dr John Q Byram
- 126. The excellent esthetic restorative material is:**  
 A. Silicate                              B. Composite resins  
 C. Porcelain                          D. All of the above
- 127. The fillers mostly used for composite resin are quartz and lithium aluminum silicate glass because they exhibit:**  
 A. Low thermal dimensional change  
 B. A translucency matching tooth structure  
 C. Chemical inertness  
 D. All of the above
- 128. Most conventional 'macrofilled' restorative resins contain fillers by weight upto:**  
 A. 50 to 60 %                      B. 60 to 70 %  
 C. 70 to 80 %                      D. 80 to 90 %
- 129. The highly cross linked available resin systems are:**  
 A. BisGMA                              B. Urethane diacrylates  
 C. 4-META                              D. Both A and B
- 130. The setting reaction for composite resins is free radical polymerization. The initiator of polymerization using visible light is:**  
 A. Benzoyl peroxide  
 B. Tertiary amine  
 C. Photosensitive diketone compounds  
 D. Camphoroquinone
- 131. The surface hardness of composite resins when compared with unfilled resin is:**  
 A. Same  
 B. Almost twice of unfilled resin  
 C. Approx. 4 times of unfilled resin  
 D. None of the above
- 132. In composite restorative material, the bond present between filler particles and polymer is:**  
 A. Hydrogen bond  
 B. Ionic bond  
 C. Silane bond  
 D. None of the above
- 133. All of the following statements are true for composite resins except:**  
 A. Improved dimensional stability  
 B. Decreased thermal coefficient of expansion  
 C. High resistance to abrasion  
 D. There is less marginal leakage

## 392 Textbook of Operative Dentistry

- 134. The recently evolved and more popular generation of filled resin is:**
- Microfilled resin
  - Hybrid resins
  - Small particle resins
  - All of the above
- 135. In preparing a class 3 cavity for restorative resins, the most prominent retention groove is placed within:**
- Incisal wall
  - Axial wall
  - Cervical wall
  - Pulpal wall
- 136. The axial wall of the class V cavity preparation is:**
- Flat
  - Concave
  - Convex
  - Convex only inciso-cervically
- 137. Which of the following cavosurface margins is not beveled in "class IV" cavity preparation for restorative resins?**
- Labial
  - Lingual
  - Cervical floor
  - None of the above
- 138. A base or liner which is contraindicated beneath filled or unfilled resins is:**
- Glass ionomer
  - Calcium hydroxide
  - Polycarboxylate cement
  - Zinc oxide-eugenol
- 139. The usual sequence of restoration class (type) D depth cavity with composite resin is:**
- Glass ionomer, calcium hydroxide, filled resin
  - ZnO-Eugenol, glass ionomer and filled resin
  - Calcium hydroxide, glass ionomer and filled resin
  - Glass ionomer, calcium hydroxide and filled resin
- 140. The angle of pulling mylar matrix strip for class III cavity preparation with filled resin is towards:**
- Gingival direction
  - The access opening
  - Incisal direction
  - Mesial direction
- 141. The most popular resin system in clinical practice is:**
- Unfilled resin system
  - Chemically activated resin system
  - Photo-activated resin system
  - All of the above
- 142. For photo initiated resin system, the optimum depth of cure is obtained with emitting orifice held:**
- Within 4 mm of resin surface
  - Slightly touching resin surface
  - Within 1 mm of resin surface
  - Within 3 mm of resin surface
- 143. Finishing of the composite resin is done by:**
- Diamond stones and silicon carbide disks
  - Fine aluminum oxide and silicon carbide disks
  - Quartz and diamond stones
  - Iron oxide and silicon carbide disks
- 144. Shade determination is easier during esthetic restoration for:**
- Tetracycline staining
  - Modifying tooth color
  - Modifying tooth contour
  - Fluorosis
- 145. When there is no need to support functional stresses, the choice of composite resin in esthetic restoration is:**
- Hybrid composite resin
  - Macrofilled composite resin
  - Microfilled composite resin
  - Small particle composite resin
- 146. A patient comes with esthetic complaint. It was found on examination that teeth are thin labiolingually. The material for maintaining tooth color and contour is:**
- Microfilled composite resin
  - Hybrid composite resin
  - Conventional composite resin
  - Small particle composite resin
- 147. With composite resin restoration, finishing of margins is done in sequence of:**
- Occlusal, proximal and cervical
  - Proximal, cervical and occlusal
  - Cervical, proximal and occlusal
  - There is no sequence

|       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 134 B | 135 C | 136 C | 137 C | 138 D | 139 C | 140 C | 141 C | 142 C |
| 143 B | 144 C | 145 C | 146 B | 147 C |       |       |       |       |

- 148. The esthetic restorative materials minimizing/reducing the possibility of secondary caries are:**
- Glass ionomer and composite resins
  - Composite resins and silicate
  - Silicate and glass ionomer cement
  - Calcium hydroxide and silicate
- 149. The liquid system of glass ionomer restorative material is essentially:**
- Polyalkanoic acid
  - Phosphoric acid
  - Polyacrylic-itaconic acid
  - None of the above
- 150. The significant properties of the glass ionomer restorative material include:**
- Chemical bonding with enamel and dentin
  - Biocompatibility
  - Release of fluoride with set material
  - All of the above
- 151. It has been found that direct veneer restorations have more limited prognosis and tendency to discolor within:**
- 1 to 2 years
  - 3 to 5 years
  - 5 to 7 years
  - None of the above
- 152. An aged patient with high caries index has class III carious lesion extending onto the root surface. Material of choice to restore the carious lesion is:**
- Composite resin
  - Silicate cement
  - Glass ionomer cement
  - Polycarboxylate cement
- 153. Which of the following is/are used to remove the 'smear' layer of dentin surface?**
- Polyacrylic acid
  - EDTA
  - Tannic acid
  - All of the above
- 154. Currently the most effective agent for removing smear layer while retaining the dentinal plug is:**
- Tannic acid
  - EDTA
  - Citric acid
  - Polyacrylic acid
- 155. The region of tooth more challenging to restore with greatest change in 'chroma' is:**
- Labial surface
  - Incisal surface
  - Cervical third
  - Proximal surface
- 156. In indirect veneering, labial surface preparation removes approx. 0.5 to 1 mm enamel and margins are prepared slightly incisal to free gingival crest with a finish line as:**
- Shoulder with bevel
  - Knife edge
  - Chamfer finish line
  - Shoulder
- 157. Most of the direct filling golds are:**
- 20 karat
  - 22 karat
  - 24 karat
  - 18 karat
- 158. Electralloy is:**
- Mat gold wrapped in gold foil
  - Mat gold alloyed with calcium and wrapped in gold foil
  - Powdered gold
  - Platinized gold
- 159. Annealing of direct filling gold is done:**
- To make it cohesive
  - To make it non-cohesive
  - To weld the pieces of gold
  - To develop strength
- 160. Dr GV Black laid the scientific foundation of cavity preparation in the year:**
- 1840
  - 1898
  - 1910
  - 1870
- 161. When restoring a tooth with direct filling gold, the condensation should begin at:**
- Margins of cavity
  - Central area of cavity
  - 45° to the walls
  - None of the above
- 162. The mechanical means of condensing direct filling gold uses:**
- Hollenback Pneumatic Condenser
  - Mc Shirley Electro-mallet
  - Both A and B
  - Hand malleting
- 163. "Mat foil" is:**
- A foil encapsulating powdered gold
  - Mat gold wrapped in fibrous gold foil
  - Fibrous gold foil
  - None of the above



**394** *Textbook of Operative Dentistry*

- 164. The most recent direct filling gold which produces the hardest surface on condensation is:**
- A. Mat gold
  - B. Encapsulated powdered gold
  - C. Mat gold alloyed with calcium and wrapped in gold foil
  - D. Platinized gold
- 165. The oldest form of direct filling gold used for restorations are:**
- A. Fibrous gold foil
  - B. Mat gold
  - C. Encapsulated powdered gold
  - D. Electraloy
- 166. Which of the following direct filling golds is used both as bulk filler and for surface restoration?**
- A. Electraloy
  - B. Mat gold
  - C. Encapsulated powdered gold
  - D. Fibrous gold foil
- 167. All of the following are true about direct filling gold except:**
- A. Mat foil is used as surface restoration
  - B. Encapsulated powdered gold is used both as bulk filler and surface restoration
  - C. Electraloy is used successfully for restoring all classes of cavity where cohesive gold is employed
  - D. Mat foil is used as bulk filler
- 168. The purpose of adding 'calcium' to mat gold is:**
- A. To increase malleability
  - B. To increase hardness and strength
  - C. To avoid pitting and void formation
  - D. All of the above
- 169. Which of the following is contraindication(s) for direct filling gold?**
- A. Very large pulp chamber
  - B. Periodontally weakened teeth
  - C. Very young and elderly patients
  - D. All of the above
- 170. Cavities prepared for direct filling gold are thoroughly cleaned, dried and cavity varnish is applied to:**
- A. Only enamel
  - B. Only dentin
  - C. Both enamel and dentin
  - D. None of the above
- 171. "Veneered gold foil" restoration is:**
- A. Electraloy restoration
  - B. Combined use of mat foil and gold foil
  - C. Mat gold wrapped in sheet of fibrous gold
  - D. None of the above
- 172. Dr GV Black classified the cavities in the year:**
- A. 1860
  - B. 1870
  - C. 1898
  - D. 1920
- 173. Direct filling gold is always worked from:**
- A. Periphery towards center of restoration
  - B. Center of restoration towards margins
  - C. Both A and B
  - D. First peripherally and then towards center of restoration
- 174. Which American Dental Association specification number covers the 'inlay casting gold'?**
- A. No. 2
  - B. No. 3
  - C. No. 4
  - D. No. 5
- 175. Majority of cast gold restorations uses:**
- A. Type I gold alloys
  - B. Type II gold alloys
  - C. Type III gold alloys
  - D. Type IV gold alloys
- 176. All of the following properties of the crown and inlay casting gold alloys increase from type I to type IV except:**
- A. Proportional limit
  - B. Tensile strength
  - C. Hardness and strength
  - D. Elongation

- 177. A basic requirement of all cavity preparation for onlay is:**
- Cavity walls must diverge from floor to occlusal surface
  - Cavity walls must converge from cervical to occlusal surface
  - Cavity walls must be parallel from cervical to occlusal surface
  - None of the above
- 178. Which of the following is true about cast gold restorations?**
- Virtually any tooth can be restored
  - Extensive tooth tissue lost by caries are restored
  - Extensive tooth tissue lost by trauma are restored
  - All of the above
- 179. Placement of bevels on cavosurface margin for cast gold restorations results in:**
- 25° metal margin
  - 25-35° metal margin
  - 45° metal margin
  - None of the above
- 180. Historically, "Slice preparation" refers to:**
- Placement of intracoronal taper
  - Placement of extracoronal taper
  - Modified flare preparation
  - None of the above
- 181. In cavity designing for cast gold, the flare of the proximal walls should form axioproximal angles of:**
- 90°
  - 45°
  - 100-110°
  - 45-90°
- 182. The least costly rubber based impression material is:**
- Addition silicon
  - Condensation silicon
  - Polysulfides
  - Polyether
- 183. Permissible delay in pouring hydrocolloid impression after removal from mouth is upto:**
- 24 hours
  - 1 hour
  - One day
  - None of the above
- 184. The position of the wax pattern within the investment mold is governed by:**
- Sprue pin
  - Investing technique used
  - Both A and B
  - None of the above
- 185. Attachment of single prue pin is made into bulky portion of pattern at an angle of about 45° to occlusal plane:**
- Slightly to buccal side
  - Slightly to lingual side
  - Almost vertically
  - Towards proximal surface
- 186. For proper venting of air and gases, the sprue length is approximately:**
- 4 to 6 mm
  - 6 to 8 mm
  - 8 to 12 mm
  - 10 to 12 mm
- 187. Most frequently used pin type is:**
- Friction locked pin
  - Cemented pin
  - Self-threading pin
  - None of the above
- 188. Which of the following correctly matched?**
- Self-threading pin was described by Going
  - Cemented pins was introduced by Markley
  - Friction locked pin was introduced by Goldstein
  - All of the above
- 189. Which of the following is true about placement of pin in amalgam restorations?**
- It improves both retention and resistance
  - It reinforces restorative material
  - It improves only retention
  - Bending of pin increases retention
- 190. Most widely used self-threading pin is:**
- Gold plated pin
  - Color coded pin
  - TMS pins
  - All of the above
- 191. All of the following are true about placement of pin except:**
- Optimum length of pin extending into amalgam is 2 mm
  - Optimum inter-pin distance is 5 mm
  - For molars and premolars respectively, 1 and 2 pins per missing cusp provide sufficient retention
  - None of the above

### 396 Textbook of Operative Dentistry

- 192. The least traumatic and most versatile pin system is:**
- Cemented wire pin
  - Self-threading pin
  - Friction locked pin
  - None of the above
- 193. The most retentive pin system is:**
- Cemented wire pin
  - Self-threading pin
  - Friction locked pin
  - None of the above
- 194. For the complex amalgam restorations, "Amalgapin technique" was developed by:**
- Markley
  - Goldstein
  - Shavell
  - Standlee
- 195. In preparing a post, the apical root canal seal necessary to prevent leakage is:**
- Minimum 2-3 mm
  - Maximum 5-6 mm
  - Half the length of obturated root canal
  - None of the above
- 196. "Richmond" or "Davis" crown is:**
- Post type porcelain crown
  - Castable ceramic crown
  - Feldspathic aluminous crown
  - Composite veneered gold crown
- 197. Fused porcelain jacket crown was developed by:**
- Dr SC Brecker
  - Dr CH Land
  - Dr RB Sozio
  - Dr RG Craig
- 198. The type of crown indicated where both esthetics and strength are required is:**
- Dicor crown
  - Porcelain Feldspathic crown
  - Porcelain fused to metal crown
  - Bonded alumina crown
- 199. The core of the aluminous porcelain jacket crown is approximately composed of:**
- 25% porcelain and 75% alumina
  - 75% porcelain and 25% alumina
  - 50% porcelain and 50% alumina
  - 80% porcelain and 20% alumina
- 200. Aluminous porcelain jacket crown was developed by:**
- John Mc Lean
  - Corning Glass Works
  - JF Johnston
  - None of the above
- 201. Dicor is a:**
- Castable ceramic restoration
  - Composite veneer restoration
  - Cerestore restoration
  - Porcelain fused to metal restoration
- 202. Dicor crown was developed by:**
- Coors Biomedical company
  - Corning Glass Works
  - John Mc Lean
  - Johnson & Johnson Dental Care
- 203. Which of the following is a contraindication for porcelain fused to metal crown?**
- Restoring multiple abutments
  - Short abutment with pin-retained restoration
  - Large pulp organ
  - None of the above
- 204. For cementation of porcelain jacket crown with zinc phosphate, the powder for color trial is mixed with:**
- Polyacrylic liquid
  - Cement liquid
  - Glycerine and water solution
  - None of the above
- 205. Remineralization of the cariously damaged tooth structure occurs as local pH:**
- Rises above 7
  - Rises above 5.5
  - Decreases below 5
  - None of the above
- 206. The term 'Odontopathic' refers to:**
- Causing disease to odontoblasts
  - Causing disease to teeth
  - Causing disease to enamel only
  - None of the above
- 207. Streptococcus mutans and lactobacilli are the primary cariogenic organisms and are said to be:**
- Acidogenic only
  - Aciduric only
  - Both acidogenic and cariogenic
  - None of the above

208. The term “Aciduric” refers to:

- A. Bacteria producing great amount of acids
- B. Bacteria capable of tolerating acidic environment
- C. Bacteria unable to tolerate acidic environment
- D. None of the above

209. The microorganisms most strongly associated with “onset of caries” and active progression of cavitated lesions are:

- A. *Staphylococcus aureus* and *Streptococcus mutans*
- B. *Staphylococcus aureus* and Lactobacilli
- C. *Streptococcus mutans* and Lactobacilli
- D. Viridans and Actinobacillus group

210. Nonspecific plaque hypothesis assumes that:

- A. All plaque are pathogenic
- B. Plaque is pathogenic only when signs of disease are present
- C. Both A and B
- D. None of the above

211. The single most important factor in producing cariogenic plaque is:

- A. High amount of glucose exposure
- B. High frequency of glucose exposure
- C. High amount of sucrose exposure
- D. High frequency of sucrose exposure

212. The teeth normally have a plaque community dominated by:

- A. *Streptococcus sanguis* and *Streptococcus mutans*
- B. *Streptococcus sanguis* and *Streptococcus mitis*
- C. Lactobacilli and *Streptococcus mutans*
- D. *Streptococcus salivarius* and lactobacilli

213. Occluprint is used for:

- A. Occlusal carving of amalgam class II filling
- B. Occlusal carving of composite resin class I filling
- C. Both of the above
- D. None of the above

214. The process of plaque regrowth after the tooth surface is cleaned is termed as:

- A. Primary succession of plaque growth
- B. Secondary succession of plaque growth
- C. Tertiary succession of plaque growth
- D. None of the above

215. Going from higher to lower demineralization of enamel starts at the pH range from:

- A. 3 to 4
- B. 5 to 5.5
- C. 6 to 7
- D. None of the above

216. The second most susceptible area of tooth to caries are:

- A. Buccal and lingual pits of molars
- B. Pit and fissures
- C. Proximal surface gingival to contact area
- D. Facial and lingual smooth surface

217. Root caries is initiated by:

- A. *Streptococcus mutans*
- B. Lactobacilli
- C. *A. viscosus*
- D. Anaerobes

218. The time for progression from incipient caries to clinical caries, i.e. cavitation on smooth surfaces is estimated to be:

- A. 15 months  $\pm$  6 months
- B. 15 months  $\pm$  8 months
- C. 18 months  $\pm$  6 months
- D. 18 months  $\pm$  3 months

219. Now-a-days cavities are prepared very conservatively because of the development of the following:

- A. Tooth colored restorative materials
- B. Adhesive restorative materials
- C. Fluoride releasing restoration material
- D. All of the above

220. What is the difference between white spot of hypocalcification and white spot of incipient caries?

- A. No difference, both are same
- B. Hypocalcified spot disappears on wetting and reappears on drying while incipient caries spot is not changed
- C. Incipient caries spot partially or totally disappears visually when hydrated while hypocalcified spot is unaffected on hydration
- D. None of the above

## 398 Textbook of Operative Dentistry

### 221. Arrested carious lesion is:

- A. Discolored and remineralized area
- B. Intact and more resistant to caries attack than adjacent unaffected enamel
- C. Not restored unless esthetically required
- D. All of the above

### 222. The deepest and advancing front of enamel carious lesion is:

- A. The dark zone
- B. The body of the lesion
- C. The translucent zone
- D. The surface zone

### 223. The zone of enamel caries which is relatively unaffected by caries attack is:

- A. The dark zone
- B. The surface zone
- C. The translucent zone
- D. The body of the lesion

### 224. Which part of tooth is least resistant to caries?

- A. Surface enamel
- B. Dentin
- C. Dentinoenamel junction
- D. Cementum

### 225. A reliable test to detect caries is:

- A. Only visual
- B. Only by use of explorer
- C. Only radiograph
- D. None of the above

### 226. Most effective treatment in preventing pit and fissure caries is:

- A. Local fluoride application
- B. Systemic water fluoridation
- C. Pit and fissure sealants
- D. Enameloplasty

### 227. Occlusal surfaces account for only of all tooth surfaces:

- A. 10.5%                      B. 12.5%
- C. 14.5%                     D. 16.5%

### 228. 'Bowen' resin is:

- A. Glyceryl methacrylate
- B. Methacrylate monomer
- C. Reaction product of glyceryl methacrylate and bisphenol A
- D. None of the above

### 229. The levels of which bacteria can be used to assess the effectiveness of caries control procedures?

- A. *Streptococcus mutans*
- B. *Staphylococcus aureus*
- C. Lactobacilli
- D. *A. viscosus*

### 230. Caries control refers to:

- A. Removal of infected tooth structure
- B. Medicating the teeth
- C. Restoring defects with temporary material
- D. All of the above

### 231. Caries control is an intermediate step in restorative treatment and most frequently used materials are:

- A. Composite resin
- B. Amalgam
- C. Amalgam and intermediate restorative material
- D. None of the above

### 232. The term "universal precautions" means:

- A. All patients are treated as infectious
- B. High risk group patients are only treated as infectious
- C. All patients and blood contaminated body fluids are treated as infectious
- D. None of the above

### 233. Carbon steel instruments and BURS are best sterilized by:

- A. Autoclave
- B. Dry heat and chemiclave
- C. Boiling water
- D. 2% Glutaraldehyde solution

### 234. The most gentle method of sterilization used for hand pieces is:

- A. Autoclaving
- B. Dry heat
- C. Ethylene oxide gas
- D. None of the above

### 235. Dry heat sterilization is readily achieved at temperatures:

- A. Above 100°C
- B. Above 160°C
- C. Above 320°F
- D. Both B and C

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|       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 221 D | 222 C | 223 B | 224 C | 225 D | 226 C | 227 B | 228 C | 229 C |
| 230 D | 231 C | 232 C | 233 B | 234 C | 235 D |       |       |       |

236. Senile caries is:

- A. Recurrent caries
- B. Residual caries
- C. Root surface caries
- D. Forward caries

237. The number of line angles in class II amalgam cavity are:

- A. 6
- B. 12
- C. 11
- D. 7

238. The term 'Idiopathic erosion' means:

- A. Loss of tooth surface by regurgitation of stomach acid
- B. Loss of tooth surface due to habitual sucking of lemon
- C. Microfractures as cervical area of tooth flexes under heavy loads
- D. None of the above

239. In "complex" cavity preparation:

- A. Only one tooth surface is involved
- B. Two surfaces are involved
- C. Three or more surfaces are involved
- D. None of the above

240. Which of the following is not an internal wall of a cavity preparation?

- A. Axial wall
- B. Pulpal wall
- C. Gingival wall
- D. All of the above

241. All of the following are external walls of a cavity preparation except:

- A. Gingival walls
- B. Axial walls
- C. Buccal wall
- D. Distal wall

242. A cavity preparation which includes both internal and external cavity walls is termed:

- A. Extracoronary preparation
- B. Intracoronary preparation
- C. Metal onlay restoration
- D. Both A and B

243. The principal retention form for cast metal restoration is:

- A. Placing retentive grooves
- B. Large angle of divergence
- C. Almost parallel vertical walls
- D. All of the above

244. 'Skirts' are retentive features usually used with:

- A. Amalgam restoration
- B. Direct filling gold restoration
- C. Cast gold restoration
- D. Ceramic restoration

245. Which of the following is an advantage of using glass ionomer material as a liner under composite restoration?

- A. It reduces recurrent caries
- B. It bonds both to tooth and composite
- C. It provides better seal when used on non-enamel margins
- D. All of the above

246. In non-cutting instruments, the part which corresponds to the blade is:

- A. Face
- B. Shank
- C. Nib
- D. Handle

247. The cutting instrument HOE is subdivision of:

- A. Hatchet
- B. Chisel
- C. Excavator
- D. Angle former

248. In an instrument formula, the second number for gingival marginal trimmer is 90-100. The angle former is used on:

- A. Mesial gingival margin
- B. Distal gingival margin
- C. Onlay preparation
- D. Facial gingival margin

249. The most important design characteristic of a 'bur' blade is:

- A. Rake angle
- B. Edge angle
- C. Clearance angle
- D. None of the above

250. For cutting hard and brittle material, the rake angle should be to increase tool life:

- A. Positive
- B. Negative
- C. Equal to long axis
- D. None of the above

251. When using diamond instrument for tooth cutting without coolants, they produce:

- A. Same damaging heat as compared to carbide bur
- B. Less damaging heat as compared to carbide bur
- C. More damaging heat as compared to carbide bur
- D. None of the above



## 400 Textbook of Operative Dentistry

- 252. Noise level which can cause hearing damage is:**
- A. 60 db
  - B. Above 75 db
  - C. 40 db
  - D. None of the above
- 253. The isthmus width for Class II amalgam cavity should be:**
- A. 1/3rd the intercuspal width
  - B. 1/4th the intercuspal width
  - C. Half the distance of intercuspal width
  - D. None of the above
- 254. Enameloplasty is indicated:**
- A. When fissure depth is no more than 1/2 thickness of enamel
  - B. When fissure depth is not more than 1/3rd thickness of enamel
  - C. Fissure depth is 2/3rd thickness of enamel
  - D. None of the above
- 255. Dental caries is said to be 'extensive' when:**
- A. It involves more than one tooth
  - B. Distance between infected dentin and pulp is less than 2 mm
  - C. Distance between infected dentin and pulp is less than 1 mm
  - D. All of the above
- 256. While condensing amalgam, a large diameter condenser nib requires:**
- A. Less condensation pressure
  - B. Greater condensation pressure
  - C. Does not depend upon diameter of condenser rib
  - D. Same pressure as of small condenser rib
- 257. Condensation time for an amalgam mix is usually:**
- A. 5 minutes
  - B. 10 minutes
  - C. 3 to 4 minutes
  - D. 6½ to 8½ minutes
- 258. Finishing and polishing of an amalgam restoration is done:**
- A. After placement of amalgam
  - B. After 12 hours of placing amalgam
  - C. After 24 hours of placing amalgam
  - D. On 3rd day of placing amalgam
- 259. While restoring a compound cavity involving linguo-occlusal surface, the close adaptation on lingual side is achieved by a matrix and green-stick compound. This was first suggested by:**
- A. Barton
  - B. Gilmore
  - C. Simonsen
  - D. Fusayama
- 260. Retention and resistance form in Class II amalgam cavity is provided by:**
- A. Occlusal dovetail
  - B. Retention groove placed in axiofacial and axiolingual line angles
  - C. Both A and B
  - D. Wider isthmus only
- 261. In preparing a Class II amalgam cavity, the proximal box surface has "reverse curve" usually in:**
- A. Facial wall
  - B. Lingual wall
  - C. Axial wall
  - D. None of the above
- 262. In an ideal conservative class II amalgam cavity, the mesiofacial and mesiolingual margins should clear adjacent teeth by:**
- A. 1 to 2 mm
  - B. 0.5 to 1 mm
  - C. 0.2 to 0.3 mm
  - D. 2 mm
- 263. The recommended creep value for amalgam should not exceed:**
- A. 5 %
  - B. 2 to 5 %
  - C. 1 %
  - D. None of the above
- 264. The Tofflemire universal matrix system is ideally indicated:**
- A. Two surface Class II restoration
  - B. Three surface cavity preparation
  - C. Class I compound cavity is prepared
  - D. All of the above
- 265. Palodent is:**
- A. Palliative cement
  - B. Calcium hydroxide liner
  - C. Commercial metal strips for matrices
  - D. None of the above

- 266. For extensive class II cavity, Automatrix is used. It is a:**
- Universal matrix system
  - Retainerless matrix system
  - Tofflemire matrix system
  - Ivory matrix system
- 267. Which of the following is a disadvantage of pneumatic condenser?**
- Damage to enamel margins
  - Inadequate condensation in conservative cavity preparation
  - Both of the above
  - None of the above
- 268. Which of the following provides retention form in class III amalgam cavity?**
- Gingival groove
  - Incisal cove
  - Lingual dovetails
  - All of the above
- 269. The best matrix system for class III amalgam cavity preparation is:**
- Wooden wedge
  - Wedge supported matrix
  - Wedged, compound-supported matrix
  - Tofflemire matrix
- 270. The best treatment for class V lesion on a tooth along with extensive class II caries is:**
- Restoration of class II followed by class V
  - Cast gold restoration
  - A full crown restoration
  - Restoration of class V followed by class II
- 271. The class V cavity preparation is:**
- Flat mesiodistally
  - Concave mesiodistally
  - Convex mesiodistally
  - None of the above
- 272. Prefabricated plastic matrices are used in:**
- Class V cavity preparations
  - Class VI cavity preparations
  - Class VII cavity preparations
  - All of the above cavity preparations
- 273. If both class II and class V lesions are present on a tooth and they are to be restored by amalgam, then best will be:**
- Class II preparation and restoration is done followed by class V
  - Class V preparation and restoration is done followed by class II
  - Both cavities are prepared and restored at same time
  - None of the above
- 274. Which of the following is true about class V amalgam cavity restoration?**
- Most restorations are done without matrix placement
  - Amalgam is condensed first in retentive areas followed by mesial and distal wall restoration
  - Finally central portion is built
  - All of the above
- 275. For amalgam capping, it is mandatory to reduce cusp when facial extension is two-thirds from primary groove toward cusp tip. It provides:**
- Adequate retention form
  - Adequate resistance form
  - Stability
  - None of the above
- 276. In pin retained amalgam restorations, which property significantly decreases:**
- Compressive strength
  - Retention
  - Tensile strength
  - All of the above
- 277. A grossly decayed tooth was restored using self-threading pin. The diameter of pin hole is:**
- Greater than the diameter of pin
  - Both have the same diameter
  - Smaller than diameter of pin
  - None of the above
- 278. Which of the following is true about self-threading pin system?**
- It is the most retentive
  - 3 to 6 times more retentive than cemented pin
  - Use of cavity varnish does not reduce retentive property
  - All of the above

## 402 Textbook of Operative Dentistry

- 279. The friction-locked pin system described by GOLDSTEIN is:**
- A. Less retentive than cemented pin
  - B. More retentive than self-threaded pin
  - C. 2-3 times more retentive than cemented pin
  - D. 3-6 times more retentive than cemented pin
- 280. Usually pinhole preparation on which tooth surfaces should be avoided?**
- A. Distal surface of mandibular molars
  - B. Lingual surface of maxillary molars
  - C. Both of the above
  - D. None of the above
- 281. The optimum pin length in amalgam of a pin retained restoration is:**
- A. 1 to 4 mm
  - B. 2 to 3 mm
  - C. 2 mm
  - D. 3 mm
- 282. In pin retained amalgam restoration, failure is more likely to occur at the:**
- A. Pin restoration interface
  - B. Pin dentin interface
  - C. Both of the above
  - D. Inside of restoration (Restoration fracture)
- 283. Which of the following is true about silicate cement restoration?**
- A. Its coefficient of thermal expansion is closer to that of enamel
  - B. It has tooth matching ability
  - C. Possesses anticariogenic property
  - D. All of the above
- 284. The "dentin bonding system" includes:**
- A. Conditioner
  - B. Primer
  - C. Bonding agent with low viscosity
  - D. All of the above
- 285. Slot preparation is done in metal cast cavity preparation to increase:**
- A. Resistance
  - B. Retention
  - C. Both of the above
  - D. None of the above
- 286. "CEREC" system is:**
- A. First commercially available CAD/CAM system
  - B. Composite resin system
  - C. Castable glass system
  - D. Light cured glass ionomer system
- 287. Major disadvantage of CAD/CAM system is:**
- A. Need for extended training
  - B. High cost
  - C. Both of the above
  - D. Designing of restoration takes more time
- 288. A notable difference in class II cavity preparation for composite and for Amalgam is in:**
- A. Proximal box
  - B. Pulpal wall
  - C. Axial wall depth
  - D. None of the above
- 289. Beveled cavity design for directly placed composites is most frequently used with:**
- A. Class VI cavity
  - B. Class II cavity
  - C. Class I cavity
  - D. All of the above
- 290. In restoring class I and class VI cavities with directly placed composites, the cavity design primarily used is:**
- A. Conventional preparation design
  - B. Beveled preparation design
  - C. Modified preparation design
  - D. None of the above
- 291. KHN for composites and DICOR is respectively:**
- A. 40 and 320
  - B. 60 and 330
  - C. 30 and 362
  - D. 30 and 343
- 292. Which of the following is used with the CEREC system?**
- A. Feldspathic porcelain
  - B. DICOR
  - C. DICOR 'MGC'
  - D. All of the above
- 293. Which material has lowest coefficient of thermal expansion?**
- A. Composite
  - B. DICOR
  - C. DICOR 'MGC'
  - D. Enamel

- 294. In providing indirect tooth-colored 'onlay', a temporary resin is given. Which cement should be avoided?**  
 A. Polycarboxylate B. Zinc oxide Eugenol  
 C. Glass Ionomer D. None of the above
- 295. The most deleterious side effect of bleaching on non-vital teeth is:**  
 A. Percolation B. Cervical resorption  
 C. Erosion D. Internal resorption
- 296. The "In-office non-vital bleaching technique" is:**  
 A. Walking bleach technique  
 B. Power bleach technique  
 C. Thermocatalytic technique  
 D. Night guard technique
- 297. Bleaching of vital teeth by "In-office technique" is called as:**  
 A. Power bleach technique  
 B. Thermocatalytic technique  
 C. Night guard technique  
 D. Walking bleach technique
- 298. Microabrasion techniques for elimination of discoloration of teeth work by:**  
 A. Removing surface enamel  
 B. Bleaching stains  
 C. Bleaching developmental defects  
 D. All of the above
- 299. The material used in 'MICROABRASION technique' to remove surface discoloration is:**  
 A. Hydrogen peroxide  
 B. Ether  
 C. Hydrochloric acid  
 D. Hydrochloric acid and pumice paste
- 300. Which of the following materials is most popular for indirect veneering technique?**  
 A. Processed composite  
 B. Cast ceramic  
 C. Feldspathic porcelain  
 D. Microfill composite
- 301. A silane primer is used to condition the internal surface of which of the following indirect veneer:**  
 A. Composite veneer  
 B. Porcelain veneer  
 C. Both of the above  
 D. None of the above
- 302. Class VII division 2 cavities are:**  
 A. Cavities on proximal surfaces of anterior teeth  
 B. Cavities on incisal edges of anterior teeth  
 C. Cavities on cusp tips of posterior teeth  
 D. Cavities in the middle third on the labial surface of anterior teeth
- 303. The gingival bevel serves which of the following purposes in cast metal restoration?**  
 A. Removal of unsupported enamel  
 B. Burnishable metal margin  
 C. A lap sliding fit at gingival margin  
 D. All of the above
- 304. In cast metal restoration, secondary flare is used to:**  
 A. Place margins into embrasures  
 B. Make margins more self-cleansing  
 C. Make enamel margin stronger  
 D. All of the above
- 305. A cast metal restoration which is an intracoronal preparation and covers one or more cusps but not all, is:**  
 A. Onlay  
 B. Inlay  
 C. Full crown  
 D. None of the above
- 306. Which is true about the cast metal 'onlay'?**  
 A. It is a extracoronal restoration  
 B. It caps all the cusps of posterior teeth  
 C. It is between inlay and full crown  
 D. All of the above
- 307. If the gingivo-occlusal height of the vertical wall of the onlay increases, then the occlusal divergence should:**  
 A. Decrease  
 B. Increase  
 C. Be same  
 D. Always decrease
- 308. In cavity preparation for cast metal onlay, counterbevel is not placed on:**  
 A. Facial cusp of maxillary premolars  
 B. Facial cusp of maxillary 1st molar  
 C. Both of the above  
 D. Facial cusp of mandibular 1st molar

## 404 Textbook of Operative Dentistry

- 309. "Skirt preparation" is thin extension of facial or lingual margins of onlay that usually:**
- Are prepared in dentin
  - Are prepared entirely in enamel
  - Improve both resistance and retention form
  - Both B and C
- 310. Which of the followings is a disadvantage of "skirt preparation"?**
- It increases the display of metal
  - It reduces resistance and retention form
  - It is prepared on unesthetic region
  - All of the above
- 311. A postoperative alginate impression is a must for temporary resin using:**
- Direct temporary technique
  - Indirect temporary technique
  - Both of the above
  - None of the above
- 312. The major disadvantage of zinc phosphate cement regarding cementation of a casting is:**
- It displays very low film thickness
  - Short working time
  - Initially it has a low pH
  - All of the above
- 313. A gold foil No. 3 weighs:**
- 3 grams
  - 3 mg
  - 3 grain
  - 3 mgm
- 314. "Extraply" is:**
- Prerolled thinner No.2 gold foil
  - Prerolled platinized gold foil
  - Electraloy R.V.
  - Powdered gold
- 315. Which of the following agents is used to prevent the formation of deleterious oxides on gold foil?**
- Methane
  - Ammonia
  - Hydrogen peroxide
  - Carbon monoxide
- 316. Degassing of gold foil is accomplished by:**
- Heating on mica tray over flame
  - An electric annealer
  - Heating over pure ethanol flame
  - All of the above
- 317. If the Nib diameter is reduced by half, and constant malleting force is given the effective compaction force delivered is:**
- Two times greater
  - Four times greater
  - Same
  - Four times lesser
- 318. For a class I cavity restored with direct filling gold, restorative phase begins with:**
- Application of cavity varnish
  - Insertion of a piece of mat gold
  - Condensation of first piece of gold
  - Application of a base
- 319. The typical class V cavity design for direct gold filling is:**
- Rhomboidal
  - Triangular
  - Square
  - Trapezoidal
- 320. In class V direct gold filling cavity, retention is provided by:**
- Facial divergence of occlusal and gingival walls
  - Facial convergence of occlusal and gingival walls
  - Mesial and distal walls
  - None of the above
- 321. Polishing of class V direct filling gold restoration is done with:**
- Aluminum oxide
  - Fine pumice
  - Diamond bur
  - All of the above
- 322. The term "occlusion" is used to designate a functional complex that includes:**
- Teeth and the jaws
  - Teeth, periodontium jaw joints
  - Teeth, nerves and muscles
  - All of above
- 323. Occlusion means bringing the jaws together during:**
- Function
  - Parafunction
  - Function and parafunction
  - None of the above

|       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 309 D | 310 A | 311 B | 312 C | 313 C | 314 A | 315 B | 316 D | 317 B |
| 318 A | 319 D | 320 B | 321 B | 322 D | 323 C |       |       |       |

- 324. The central parts of the temporomandibular joints are:**
- Vascular with motor nerve supply
  - Vascular with sensory nerve supply
  - Avascular with sensory nerve supply
  - Avascular without sensory nerve
- 325. The end point of mandibular closure with maximum intercuspation of the teeth is known as:**
- Centric relation
  - Centric closure
  - Centric occlusion
  - None of them
- 326. In centric occlusion position of central part of head of condyle occurs on the:**
- Central part of the disk of the joint
  - Peripheral part of the disk of the joint
  - Whole surface of the joint
  - Does not involve the disk of the joint
- 327. After completion of growth the adaptive capacity of the joint:**
- Increases
  - Remains same as before
  - Decreases
  - Diminishes
- 328. Centric relation refers to a:**
- Retrusive movement
  - Protrusive movement
  - Both protrusive and retrusive movement
  - None of the above
- 329. The movement which occurs in centric relation is about:**
- 2 mm
  - 10 mm
  - 25 mm
  - More than 50 mm
- 330. Class VII division I cavities are:**
- Cavities in posterior teeth on facial surface
  - Cavities on labial surface of anterior teeth in the region of incisal third without involving incisal edge
  - Cavities on lingual surface of anterior teeth
  - Cavities on cervical region on labial surface in anterior teeth
- 331. The incision, chewing and swallowing of food involves:**
- Occlusal guidance
  - Neuromuscular guidance
  - Both occlusal and neuromuscular guidance
  - Only muscular and occlusal guidance
- 332. Centric stops are those positions where:**
- Upper buccal and lower lingual cusp make contact
  - Upper lingual and lower buccal cusp make contact
  - Cusp tips or incisal edges of opposing teeth make contact
  - Upper lingual and lower buccal cusp of the posterior teeth as well as cusp tips and incisal edges of the opposing teeth make contact
- 333. With which matrix/retainer patient can bite when the matrix is in place:**
- Ivory no. 1
  - Ivory no. 8
  - Tofflemire Universal matrix retainer
  - Retainerless Walser Filling matrix
- 334. The placement of cusps, grooves and ridges in individual restorations must conform with the:**
- Mandibular movement
  - Mandibular movement and occlusion
  - Only occlusal relationship
  - None of them
- 335. Tooth contact in centric relation are found more in:**
- Swallowing
  - Swallowing and mastication both
  - Mastication
  - Assimilation
- 336. In centric occlusion and centric relation there should be:**
- Even pressure on the central part of disk of the TMJ
  - Uneven pressure on the central part of disk of the TMJ
  - No pressure on the central part of the disk of the TMJ
  - None of the above



## 406 Textbook of Operative Dentistry

- 337. Raising the bite with encroachment on the interocclusal space may result in:**
- Intrusion of teeth
  - Extrusion of teeth
  - Mesial drifting of teeth
  - Rotation of teeth
- 338. Occlusal stability is maintained by harmony between the:**
- Structural component
  - Structural and neuromuscular components
  - Neuromuscular components
  - None of them
- 339. The key to the establishment of an ideal occlusion is the correct location of:**
- Centric relation
  - Centric occlusion
  - Condylar axis
  - None of the above
- 340. Occlusal guidance side is always on the:**
- Working side
  - Balancing side
  - Both on the working as well as balancing side
  - None of the above
- 341. The areas for premature contacts in centric relation are the:**
- Mesial inclines of the maxillary teeth
  - Mesial inclines of the mandibular teeth
  - Distal inclines of maxillary teeth
  - All of them
- 342. Working side interferences are found on the:**
- Lingual inclines of the buccal cusps of the maxillary posterior teeth
  - Buccal inclines of the lingual cusps of the maxillary teeth
  - Lingual inclines of the buccal cusps of the mandibular posterior teeth
  - Lingual inclines of the buccal cusps of the both maxillary and mandibular posterior teeth
- 343. The common site of the fracture of the amalgam restorations is:**
- Mesial marginal ridge
  - Mesial cusp ridge
  - Distal marginal ridge or distal cusp ridge
  - None of them
- 344. Biting forces should be dissipated along:**
- The long axis of the tooth
  - The center of rotation of tooth
  - The center of the resistance of a tooth
  - None of the above
- 345. Free way space is also known as:**
- Silverman space
  - Closest speaking space
  - Inter occlusal gap
  - All of them
- 346. Class VII cavities are usually:**
- Abrasion cavities
  - Attrition cavities
  - Erosion cavities
  - Caused by caries
- 347. Matrix band should be:**
- Rigid
  - Elastic
  - Flexible
  - None of the above
- 348. Tofflemire universal matrix band provide only:**
- Only one wall
  - Only two walls
  - Only three walls
  - All the four walls
- 349. Acidulated fluorides should not be used in patients with:**
- Porcelain type crowns
  - Acrylic type crowns
  - Metallic crowns
  - All of the above
- 350. Deep overbite causes impingement on the:**
- Labial aspect of the mandibular incisors and palatal aspect of the maxillary incisors
  - Palatal aspect of the maxillary posterior teeth
  - Lingual aspect of the mandibular anterior teeth
  - Buccal aspect of the mandibular posterior teeth
- 351. When the lost mandibular 1st molar has not been replaced, then we see:**
- Mesial and lingual tipping of mandibular second molar
  - Distal and buccal tipping of mandibular 2nd premolar
  - Mandibular 2nd molar remains in same position
  - Supra eruption of mandibular 2nd molar

**352. When a 2nd mandibular molar has tipped close to the 2nd premolar:**

- A. 2nd mandibular molar should not be stabilized with over contoured inlay
- B. It should be stabilized with inlay
- C. It should be extracted
- D. It should be treated orthodontically

**353. Restorative dentistry with splinting of teeth is indicated when:**

- A. Tipped maxillary and mandibular molars cannot be stabilized by occlusal adjustment
- B. Fracture of the teeth
- C. Fracture of the jaw
- D. When supra-eruption of teeth occurs

**354. Pin ledge restorations with minimal contact with the gingival tissues are preferable for splinting:**

- A. Anterior tooth
- B. Posterior teeth
- C. Of the teeth of upper jaw only
- D. Both upper and lower jaws

**355. Examples of temporary splints are:**

- A. Amalgam splints
- B. Gunning splints
- C. Cast metal splints
- D. Silver coin splints

**356. If the margins of the preparation accidentally extend apically to the bottom of the epithelial attachment the injured cementum becomes covered by:**

- A. Epithelium
- B. Connective tissue
- C. Both epithelium and connective tissue
- D. It remains uncovered

**357. During cementation of inlay the main problem is:**

- A. If there is an increased mobility in the axial direction
- B. If there is an increased mobility mesially
- C. If there is an increased mobility distally
- D. None of the above

**358. Hand cutting instruments are made up of:**

- A. Acrylic
- B. Porcelain
- C. Carbon stainless steel
- D. Gold

**359. Cutting edges on carbon steel have:**

- A. Protective plating
- B. No protective plating
- C. Some of the instruments have protecting plating, but some of them do not have protecting plating.
- D. None of the above

**360. Cutting edges are dulled by:**

- A. Oiling
- B. Preserving them for a long time
- C. Contact with hard tooth structures
- D. By cold sterilization

**361. Sharpening is done by:**

- A. Acrylic block
- B. Arkansas wheel
- C. Sterilization
- D. None of the above

**362. Magnifying loupes in the sharpening instruments are useful for:**

- A. Sharpening the cutting edge
- B. Smoothing the cutting edge
- C. Blunting the cutting edge
- D. Evaluating the condition of the cutting edge

**363. Sharp pulpal pain/disappearing on removed of the stimulus is frequently a sign of:**

- A. Irreversible pulpitis
- B. Reversible pulpitis
- C. Acute pulpitis
- D. Chronic pulpitis

**364. Cracked tooth syndrome is characterized by:**

- A. Sharp pain following application of cold
- B. Sharp pain following application of heat
- C. Severe pain while eating
- D. All of the above mentioned

**365. Tooth feels elongated and sensitive to percussion in:**

- A. Cracked tooth syndrome
- B. Reversible pulpitis
- C. Irreversible pulpitis
- D. None of them

**366. If a fractured tooth is non-restorable it should be:**

- A. Reimplanted
- B. Splinted to another tooth
- C. Provided interim restoration
- D. Extracted

|       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 352 A | 353 A | 354 A | 355 A | 356 A | 357 B | 358 C | 359 B | 360 C |
| 361 B | 362 D | 363 B | 364 C | 365 C | 366 D |       |       |       |

**408** *Textbook of Operative Dentistry*

**367. Vital intruded tooth usually re-erupts by itself after a period of:**

- A. 1 month                      B. 2 months
- C. 4 months                    D. 6 months

**368. Electric pulp testers will not normally respond in case of fractured tooth involving pulp after the duration of:**

- A. 2 days                      B. 1 month
- C. 3 months                    D. 6 months

**369. Avulsed teeth should be stabilized by:**

- A. Porcelain jacket crown
- B. Stainless steel crown
- C. Orthodontic wiring
- D. Splinting

**370. Over contoured buccal or lingual surfaces can result in:**

- A. Cheek biting
- B. Food accumulation
- C. Open proximal contact
- D. Tooth malpositioning

**371. At the age of 50 years large carious lesions involving most of the cusps in posterior teeth can be best restored by:**

- A. Cast gold onlays
- B. Direct gold restoration
- C. Pin retained amalgam
- D. Both A and B

**372. Prefabricated plastic matrices are used in:**

- A. Class V cavity preparations
- B. Class I cavity preparations
- C. Class II cavity preparations
- D. All the above cavity preparations

**373. Cast restorations are most helpful in correcting periodontal problems by:**

- A. Restoring lost tooth structure
- B. Forming the splints
- C. Creating ideal occlusion
- D. None of the above

**374. An inlay is:**

- A. Any cast gold restoration
- B. Direct gold restoration
- C. Intracoronar restoration fabricated extraorally
- D. None of above

**375. Inlays are fabricated of:**

- A. Gold
- B. Ceramic
- C. Resin
- D. All of the above

**376. The property of gold which allows for a better marginal seal is:**

- A. Ductility
- B. Resistance of corrosion
- C. Tensile strength
- D. Malleability

**377. Calcicum hydroxide is used as a pulp capping agent because it:**

- A. Provides good thermal insulation
- B. Provides a mild irritant action on pulp
- C. Provides a soothing action on pulp
- D. All of the above

**378. The outline form for inlays is:**

- A. Wider than for amalgam
- B. Dependent on the extent of destruction
- C. Narrower than for amalgam
- D. Same as that for amalgam

**379. Ideally inlay cavity walls should be:**

- A. Tapered occlusally
- B. Flared occlusally
- C. Flared proximally
- D. Straight and parallel

**380. Indirect cast gold restorations are primarily finished and polished:**

- A. After cementation
- B. After casting is tried on tooth
- C. Before casting is tried on tooth
- D. None of the above

**381. The factor which contributes maximum for retention of an onlay is:**

- A. Flat pulpal and gingival wall
- B. Near parallel walls
- C. Contra (Reverse) bevels
- D. None of the above

**382. The most critical factor for retaining the casting is:**

- A. Luting cement              B. Depth of cavity
- C. Dovetails                  D. Taper of walls

---

|       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 367 D | 368 B | 369 D | 370 A | 371 A | 372 A | 373 C | 374 C | 375 D |
| 376 D | 377 B | 378 B | 379 D | 380 C | 381 A | 382 D |       |       |

**383. The bevelled margin for gold inlay cavity:**

- A. Exposes greater cement liner
- B. Allows for a thin metal margin which is unable to withstand occlusal load
- C. Has no effect on cement liner
- D. Reduces amount of exposed cement liner

**384. The cavosurface margin of gold inlay preparation should be:**

- A. Feather edge
- B. At right angles
- C. Chamfer
- D. Beveled

**385. Type IV gold alloy is not suitable for a simple inlay because:**

- A. Its hardness is so high that it will cause tooth abrasion
- B. It is too ductile and will distort
- C. It has poor marginal adaptation
- D. None of the above

**386. In inlay preparations the axiopulpal depth should be:**

- A. More in comparison to that of amalgam preparation
- B. Similar to that of amalgam preparation
- C. Less in comparison to that of amalgam preparation
- D. All of the above

**387. A cast restoration is maintained in position under masticatory load primarily by virtue of:**

- A. Obtuse cavosurface angle
- B. Cement seal
- C. The retention and resistance form
- D. None of the above

**388. While preparing the Porcelain inlay cavity the bur should be held:**

- A. Parallel to long axis of crown
- B. Parallel to long axis of root
- C. Perpendicular to occlusal plane
- D. Parallel to the line of withdrawal

**389. The outline form for cast restoration is produced by:**

- A. Slight tapered fissure bur
- B. Safe ended bur
- C. Straight fissure bur
- D. Highly tapered fissure bur

**390. A gold inlay for class I cavity in a posterior tooth having life expectancy of 10 years in a patient having heavy masticatory force is considered when:**

- A. Proximal surface caries is active
- B. Patient is about 50 years old
- C. If there is a pinpoint exposure of the pulp
- D. If caries extends to undermine the proximal margins

**391. The isthmus width for gold inlay is generally:**

- A.  $\frac{1}{3}$  intercuspal distance
- B.  $\frac{1}{2}$  intercuspal distance
- C.  $\frac{1}{4}$  th intercuspal distance
- D. None of the above

**392. A secondary flare is given to:**

- A. Gingival wall
- B. Facial and lingual proximal walls
- C. There is no such term existing with respect to inlay
- D. Facial and lingual wall

**393. In MOD preparation for gold inlays, gingival margin should be:**

- A. Chamfer
- B. Shoulder
- C. Beveled
- D. None of the above

**394. In MOD preparation for gold inlays, gingival bevel should be:**

- A.  $15^\circ$
- B.  $45^\circ$
- C.  $30^\circ$
- D.  $2^\circ$

**395. The cavity wall towards the line of withdrawal of wax pattern for inlay should have a taper of:**

- A. 30 to  $45^\circ$
- B. 5 to  $10^\circ$
- C. 2 to  $5^\circ$
- D. None of the above

**396. During cusp reduction the reverse (contra) bevel is:**

- A.  $\frac{1}{3}$ rd that of inside bevel
- B. Half the thickness of inside bevel
- C. Same as the inside bevel
- D. A and C

**397. For gold inlay the occlusal cavosurface bevel is approximately:**

- A.  $15^\circ$
- B.  $30^\circ$
- C.  $45^\circ$
- D. 8- $10^\circ$

## 410 Textbook of Operative Dentistry

- 398. To avoid distortion the thickness of rubber base impression material should be:**
- More than 4 mm
  - At least 3 mm
  - About 2 mm
  - Maximum in the area of operation
- 399. For maximum accuracy the die from alginate impression should be poured:**
- Within 24 hours
  - Within 30 minutes
  - Within 2 hours
  - After 1 hour
- 400. Marginal leakage due to temperature change can occur maximum with:**
- Unfilled resin
  - Direct filling gold
  - Composite resin
  - Amalgam alloy
- 401. Inlay waxes used for the direct method procedure possess:**
- Greater flow below 37°
  - Minimum flow above 37°
  - Minimum flow below 37°
  - Greater flow above 37°
- 402. Inlay wax patterns should be invested as soon as possible in order to minimize change in dimensions caused by:**
- Continued expansion of wax
  - Reduced flow
  - Relaxation of internal stress
  - Water absorption
- 403. An ideal location to attach a sprue pin in a wax pattern is:**
- Thickest point
  - Thinnest point
  - Anywhere
  - Where carving is least disturbed
- 404. The initial procedure in fitting a MOD gold inlay casting to a tooth is:**
- Adapt accessible margins
  - Adjust occlusion
  - Adjust the contact areas
  - Seat the casting with mallet
- 405. The most commonly used type(s) of gold alloy is:**
- Type I
  - Type II
  - Type III
  - Types I and IV
- 406. Before amalgam refilling refining of proximal margins of a cavity can be done by:**
- Angle former
  - Biangle chisels
  - Enamel hatchets
  - Both B and C
- 407. The gold alloys have a melting range of:**
- 1000 to 1400°F
  - 1700 to 1900°F
  - 2300 to 2380°F
  - 4000 to 5000°F
- 408. Discoloration of the tooth under big amalgam restoration can be prevented by:**
- Using cavity varnish
  - Using correct alloy: mercury ratio
  - Using zinc phosphate cement base
  - Washing the prepared cavity with NaOCl<sub>3</sub>
- 409. Which procedure removes oxides from the casting:**
- Tempering
  - Annealing
  - Degassing
  - Pickling
- 410. The incisal step for class IV cavity for Gold Type II inlay is indicated:**
- When less than ¼ of incisal length is involved
  - To arrest attritional wear
  - Both A and B
  - None of the above
- 411. In groove and post design of an anterior porcelain inlay the groove is placed on:**
- Axial wall
  - Gingival wall
  - Incisal edge
  - Gingivo-axial line angle
- 412. Platinised gold foil is manufactured by:**
- Electroplating gold with platinum
  - Alloy of platinum and gold
  - Electro precipitation of platinum on gold foil
  - Laminating platinum foil between two sheets of gold foil

**413. Mat gold is made by:**

- A. Electrolytic precipitation
- B. Chemical precipitation
- C. Beating pure gold into sheets
- D. Atomization

**414. Condenser nibs have:**

- A. Carbon tips
- B. Pyramidal serrations
- C. Rectangular serrations
- D. Smooth with no serrations

**415. Fine powdered gold wrapped in gold foil is known as:**

- A. Mat foil
- B. Electraloy
- C. Goldent
- D. Atomized gold

**416. Degassing of Goldent is done by:**

- A. Heating over a wax flame
- B. Heating on mica table over an ethanol flame
- C. Keeping for 10 minutes in a dry heat oven
- D. Electric annealer

**417. Direct gold fillings are contraindicated in:**

- A. Class V cavities
- B. Filling of access openings in root canal treated teeth
- C. Class III cavities
- D. Very small class I cavity

**418. Degassing renders the gold:**

- A. Sterilized
- B. Adhesive
- C. Polished
- D. Cohesive

**419. Most commonly used gold foil is:**

- A. No 3 foil
- B. No 4 foil
- C. No 2 foil
- D. None of the above

**420. Electroloy is mat gold alloyed with:**

- A. Calcium
- B. Copper
- C. Platinum
- D. Silver

**421. 'Extraply' is a term used for:**

- A. Platinized gold foil
- B. No. 4 foil
- C. Prerolled cylinders of No. 2 or No. 4 foil wrapped around a regular gold rope
- D. None of the above

**422. Another term which was previously used for degassing was:**

- A. Purifying
- B. Tempering
- C. Disinfecting
- D. Annealing

**423. The malleting force is directed:**

- A. Parallel to long axis of crown
- B. Perpendicular to the walls
- C. 45° to the wall
- D. None of the above

**424. If the nib diameter is reduced by half the compaction force is:**

- A. 4 time more
- B. Doubled
- C. Also halved
- D. Force remains the same

**425. For direct gold filling in the class V cavity the axial wall meets the gingival wall:**

- A. At right angle
- B. In acute angle
- C. In rounded shape
- D. In obtuse angle

**426. The cavosurface margin for direct gold filling are prepared with:**

- A. 45° bevel
- B. 90° butt joint
- C. 30°-40° bevel
- D. None of the above

**427. Direct filling gold is heated prior to its condensation for the purpose of:**

- A. Removing surface contaminants
- B. Recrystallization
- C. Sterilization
- D. Softening

**428. The gold used to form bulk of filling is:**

- A. Powdered gold
- B. Gold foil
- C. Mat gold
- D. Platinised foil

**429. Cohesion of direct filling gold at room temperature is an example of:**

- A. Welding
- B. Wedging
- C. Annealing
- D. Atomic attraction

**430. The amount of force required to compact the direct filling gold is influenced most by:**

- A. Temperature at which gold was annealed
- B. Surface area of condensor
- C. Angle of compaction
- D. Temperature at which gold was degassed



## 412 Textbook of Operative Dentistry

- 431. The approximate maximum speed at which an air turbine hand piece works is:**
- A. 10,000 to 15,000 rpm
  - B. 360,000 to 400,000 rpm
  - C. 900,000 to 1000,000 rpm
  - D. 6,000 to 7,000 rpm
- 432. Cavities of the cusp tips of the posterior teeth are:**
- A. Class I cavities
  - B. Class II cavities
  - C. Class IV cavities
  - D. Class VI cavities
- 433. The time required for remineralization of dentin after placement of temporary restoration is about:**
- A. 2-6 weeks
  - B. 8-16 weeks
  - C. 18-26 weeks
  - D. 30-40 weeks
- 434. Cavities occurring on the lingual fossa of incisors are:**
- A. Class VI cavities
  - B. Class IV cavities
  - C. Class III cavities
  - D. Class I cavities
- 435. The intercusp width of an ideal class I cavity (occlusal) preparation for amalgam should be:**
- A.  $\frac{1}{2}$
  - B.  $\frac{1}{3}$
  - C.  $\frac{1}{4}$
  - D.  $\frac{3}{4}$
- 436. Which wall is the base of class III preparation:**
- A. Gingival
  - B. Axial
  - C. Facial
  - D. Lingual
- 437. The purpose for retention form in cavity preparation is to prevent displacement of the restoration by:**
- A. Occlusal forces
  - B. Lateral forces
  - C. Lifting forces
  - D. All of the above
- 438. The optimal depth in dentin for self-threaded pin system is:**
- A. 2 to 3 mm
  - B. 0.5 to 1 mm
  - C. 1.5 to 2 mm
  - D. There is no optimal depth for the pin
- 439. Cavity varnishes can be used under all types of restorations except:**
- A. Cast gold
  - B. Amalgams
  - C. Resins
  - D. Ceramic
- 440. A posterior tooth with cusps undermined with caries may achieve maximum masticatory efficiency if restored by:**
- A. Silver amalgam
  - B. Direct gold
  - C. Pin retained amalgam
  - D. Cast gold after amalgam filling as a base in undermined areas
- 441. Depth of hole of cemented pins should be:**
- A. 1 to 2 mm
  - B. 3 to 4 mm
  - C. 2 to 3 mm
  - D. Similar to that of self-threaded pins
- 442. For effective thermal insulation the minimal thickness of zinc phosphate base should be:**
- A. 0.5 mm
  - B. 0.25 mm
  - C. 0.75 mm
  - D. 2.00 mm
- 443. The amalgam restoration should be burnished after:**
- A. 2 to 3 minutes
  - B. 10 to 15 minutes
  - C. 1 hour
  - D. 24 hours
- 444. Friction locked pins are retained by:**
- A. Luting cement
  - B. Threads on the pin
  - C. Longer channel depth
  - D. Resiliency of dentin
- 445. Cavity varnishes are contraindicated under:**
- A. Zinc polycarboxylate bases
  - B. Zinc oxide base
  - C. Both A and B
  - D. None of the above
- 446. The pins of choice in pulpotomized or root canal treated teeth are:**
- A. Friction locked pins
  - B. Cemented pins
  - C. Self-threaded pins
  - D. Self-shearing pins
- 447. Cavity varnish is indicated under amalgam restorations because it:**
- A. Is an effective thermal insulator
  - B. Prevents galvanic currents from reaching the pulp
  - C. Improves the marginal seal
  - D. None of the above

- 448. The best material for sedation of dental pulp is:**  
 A. Zinc oxide eugenol  
 B. Zinc phosphate  
 C. Calcium hydroxide  
 D. All of the above
- 449. An incipient carious lesion on an interproximal surface is usually located:**  
 A. Lingual to contact area  
 B. At the contact area  
 C. Facial to contact area  
 D. Gingival to contact area
- 450. Using excessive number of pins in a restoration:**  
 A. Reinforces the amalgam  
 B. Has no significant effect on strength  
 C. Weakens the restoration  
 D. Reinforces the tooth
- 451. Which is the weakest phase of the set amalgam?**  
 A. Beta-1  
 B. Gamma-1  
 C. Gamma-2  
 D. Gamma
- 452. In the TMS system:**  
 A. The pin is undersized  
 B. The pin is slightly oversized  
 C. The pin and channel are of equal length  
 D. The pin and channel are exactly of the same diameter
- 453. The function of pins in large amalgam restoration is to:**  
 A. Increase retention of amalgam  
 B. Increase tensile strength of amalgam  
 C. Both A and B  
 D. None of the above
- 454. A bacteria not associated with caries process is:**  
 A. *Streptococcus mutans*  
 B. *Lactobacillus acidophilus*  
 C. *Staphylococcus aureus*  
 D. *Actinomyces*
- 455. When ages are equal, studies have shown that young girls have slightly higher caries index than boys. This is attributed to:**  
 A. Girls eat more sweets  
 B. Hormonal differences  
 C. Earlier growth spurt in girls  
 D. Earlier eruption of dentition in girls
- 456. Clinically the earliest evidence of caries is:**  
 A. Sensitivity to sweets  
 B. Roughness on the surface of tooth  
 C. Brown area on tooth surface  
 D. Chalky white area on the tooth
- 457. The least microleakage among all dentin pin systems is exhibited by:**  
 A. Cemented pins  
 B. TMS system  
 C. Friction locked pins  
 D. None of the above
- 458. When three or more pin holes are placed in dentin they should be:**  
 A. At different levels  
 B. At least 1 mm apart  
 C. At the same level  
 D. At different depths
- 459. The minimum clearance around the pin for condensation of amalgam is:**  
 A. 0.5 mm  
 B. 1.5 mm  
 C. 1.0 mm  
 D. None of the above
- 460. The direction of retentive pin holes should be:**  
 A. At right angles to dentinal tubules  
 B. Parallel to long axis of the tooth  
 C. In the direction of long axis of tooth and parallel to nearest external surface  
 D. None of the above
- 461. Polishing of an amalgam restoration is done best:**  
 A. After 24 hours  
 B. After 72 hours  
 C. After 96 hours  
 D. None of the above
- 462. The pin channel must be prepared:**  
 A. Outside the dentinoenamel junction  
 B. 2 mm away from pulp chamber  
 C. 0.5 mm inside the DEJ  
 D. Both B and C
- 463. Fluoride-richness of surface enamel:**  
 A. Remains constant  
 B. Increases with age  
 C. Increases in increments  
 D. Decreases with time due to occlusal wear

## 414 Textbook of Operative Dentistry

- 464. At concentration higher than 50% of phosphoric acid the depth of etch is found to:**
- A. Remain constant
  - B. Increase
  - C. Decrease
  - D. Does not apply since phosphoric acid is not used for etching
- 465. A person suffering from xerostomia is more likely to have:**
- A. Cemental caries
  - B. Decrease in dental caries
  - C. Increase in lesions of dental caries
  - D. Arrested caries
- 466. Delayed expansion of amalgam starts:**
- A. After 2 years
  - B. After 24 hours
  - C. After 3-5 months
  - D. After 3-5 days
- 467. The presence of zinc in amalgam alloy:**
- A. Causes delayed expansion of the restoration
  - B. Minimises the formation of oxides
  - C. Both A and B
  - D. None of the above
- 468. The minimum strength of amalgam restoration after 1 hour should be:**
- A. 40 MPa
  - B. 60 MPa
  - C. 80 MPa
  - D. 120 MPa
- 469. After few months the marginal leakage in dental amalgam restoration:**
- A. Increases due to low edge strength of amalgam
  - B. Increases due to vaporization of mercury
  - C. Decreases due to formation of corrosion products
  - D. Decreases due to delayed expansion of amalgam.
- 470. The purpose of acid etching is:**
- A. To produce surface irregularities in which resins can penetrate
  - B. To produce a clear enamel surface
  - C. To increase the surface area of enamel
  - D. All of the above
- 471. A glazing agent is applied to the surface of a composite resin restoration in order to:**
- A. Improve the marginal seal
  - B. Increase surface smoothness
  - C. Improve aesthetics
  - D. Both B and C
- 472. The purpose of operative and restorative dentistry is to restore and maintain**
- A. Health of natural dentition
  - B. Function of natural dentition
  - C. Esthetic appearance
  - D. All of the above
- 473. Future relationship between the margin of restorations and gingival tissue can be assessed by areas of gingival inflammation and periodontal disturbances only:**
- A. About 1 day after prophylaxis and instruction of good home care
  - B. About 1 week after prophylaxis and instruction of good home care
  - C. About 1 month after prophylaxis and instruction of good home care
  - D. About 1 month after prophylaxis
- 474. Dental restoration extending subgingivally can be placed in all of the following conditions of gingiva except:**
- A. Thin gingival margin closely adapted to enamel
  - B. Papillae filling the interproximal spaces
  - C. Firm and uniform pale pink color and with or without melanin pigmentation
  - D. Bleeding of gingiva on slight probing or touch
- 475. The main reason/s for subgingival placement of margins of restoration is/are:**
- A. Subgingival fractures of teeth, position of caries, or placement of previous restorations
  - B. Esthetic
  - C. Retention and prevention of fractures
  - D. All of the above
- 476. Subgingival margins of restoration should not be placed:**
- A. More than 2 mm under the free gingival margin
  - B. More than 0.5 to 1 mm under the free gingival margin
  - C. More than 3 mm under the free gingival margin
  - D. All of the above

**477. Overcontoured crowns enhance:**

- A. Supragingival plaque accumulation
- B. Subgingival plaque accumulation
- C. Both of the above
- D. None of the above

**478. In a tooth with no caries fine occlusion and no sensitivity to percussion and in whom pain is brought about only by biting on something or release of pressure, the probable diagnosis is:**

- A. Hypersensitive dentin
- B. Acute reversible pulpitis
- C. Cracked tooth syndrome
- D. Acute apical periodontitis

**479. Pin retained cast restorations are indicated in which conditions:**

- A. Cuspal fracture where large occlusal inlays and onlays are to be prepared
- B. When occlusogingival height is very short for example in severely attrited posterior teeth
- C. When crown preparation is excessively tapered, leading to reduced retention
- D. All of the above

**480. The duration of dentinal pain is:**

- A. Greater than 5 minutes
- B. About 4 minutes
- C. Less than 1 to 3 seconds
- D. Less than 1 to 3 minutes

**481. The duration of pulpal pain is:**

- A. Greater than 5 seconds
- B. Greater than 5 minutes
- C. Less than 5 minutes
- D. Less than 1 to 3

**482. There is greater potential for thermal sensitivity to:**

- A. Gold castings
- B. Amalgam restorations
- C. Composite restorations
- D. Silicate restorations

**483. All of the following are anti sialogogues except:**

- A. Anticholinergic agent
- B. Propantheline bromide
- C. Diazepam
- D. Pro-Banthine (USP)

**484. Treatment of hypersensitive dentin is:**

- A. Plaque removal
- B. Burnishing dentine with 33% sodium fluoride/Kaolin/glycerine paste
- C. Obturation of carious lesions
- D. All of the above

**485. Steele's Siqveland self-adjusting matrix holder is suitable for:**

- A. Deciduous anterior teeth
- B. Ovoid teeth
- C. Tapering teeth
- D. None of the above

**486. Enamel etched by a tooth conditioner but not covered with a fissure sealant will:**

- A. Remineralize within a month
- B. Remineralize within 3 months
- C. Absorb stain and discolor the tooth
- D. Leave the tooth more susceptible to caries attack

**487. Microabrasion involves the use of:**

- A. Sulphuric acid    B. Acetic acid
- C. Phosphoric acid    D. Hydrochloric acid

**488. Which of the following matrix/retainer can be used as cotton wool roll holder:**

- A. Retainerless Walser Filling matrix
- B. Ivory no. 1
- C. Ivory no. 8
- D. S-shaped matrix

**489. Chemiclave is:**

- A. Chemical means of sterilization
- B. Alternative means of sterilization by chemical steam under pressure
- C. Oil of clove
- D. None of the above

**490. Width of the rubber dam for successful use is:**

- A. 4 and 6 inch    B. 5 and 6 inch
- C. 6 and 8 inch    D. 7 and 9 inch

**491. Working side interference's are found on the:**

- A. Lingual inclines of the buccal cups of the maxillary posterior teeth
- B. Buccal inclines of the lingual cusps of the maxillary teeth
- C. Lingual inclines of the buccal cusps of the mandibular posterior teeth
- D. Lingual inclines of the buccal cusps of the both maxillary and mandibular posterior teeth

**416** *Textbook of Operative Dentistry*

- 492. In inlay preparations the axiopulpal depth in comparison to amalgam should be:**  
A. More                      B. Similar  
C. Less                      D. All of the above
- 493. The strength of dental investment for gold alloy is dependent on the amount of:**  
A. Silica                      B. Carbon  
C. Copper                      D. Gypsum
- 494. Maximum permissible setting expansion of high strength stone is:**  
A. 0.1%                      B. 0.05%  
C. 0.3%                      D. 0.25
- 495. Coefficient of thermal expansion currently available porcelain is:**  
A.  $6 \times 10^{-6}/^{\circ}\text{C}$                       B.  $8 \times 10^{-6}/^{\circ}\text{C}$   
C.  $10 \times 10^{-6}/^{\circ}\text{C}$                       D.  $14 \times 10^{-6}/^{\circ}\text{C}$
- 496. The following is the list of elastomeric impression materials, which is the most biocompatible?**  
A. Polysulfide  
B. Polyether  
C. Addition silicone  
D. Condensation silicone
- 497. Which of the following dental material shows most tear resistance?**  
A. Polysulfide  
B. Condensation silicone  
C. Addition silicone  
D. Polyther
- 498. Crucible indicated for casting base metal alloys is:**  
A. Carbon crucible  
B. Clay crucible  
C. Quartz crucible  
D. High melting plastic crucible
- 499. Passivating alloys are:**  
A. Cr, Al, Ti                      B. Cr, Mo, Ti  
C. Cr, Fe, Mo                      D. Cr, Gold, Ti
- 500. Monophase elastomeric impression materials are based on:**  
A. Putty  
B. Heavy body  
C. Regular body  
D. Light body
- 501. External outline form of the cavity is influenced by all except:**  
A. Proximity to the pulp  
B. Tooth position in the area  
C. Type of restorative material  
D. Spread of caries
- 502. Extension of buccal and lingual walls in class II prep is determined by:**  
A. Extension of carious lesion gingivally  
B. Position of adjacent tooth contacts  
C. Line angles of the tooth to be restored  
D. All of the above
- 503. Crossing the oblique ridge in maxillary permanent first molar is permissible in all except:**  
A. When the ridge has a deep fissure  
B. When the ridge is undermined with caries  
C. When it is necessary for retention  
D. In incipient caries in mesial and distal pits
- 504. The most common cause for fracture of proximal part of class II amalgam restoration is:**  
A. Improper resistance form of cavity  
B. Inadequate retention at proximal portion  
C. Improper outline form of cavity  
D. Improper convenience form of cavity
- 505. Amalgam which exhibits least creep and marginal breakdown is:**  
A. High copper admixed alloy  
B. High copper spherical alloys  
C. Conventional lathe cur alloys  
D. Conventional admixed alloys
- 506. Resistance to proximal displacement in a class II amalgam cavity is provided by:**  
A. Converging proximal walls  
B. Occlusal dove tail  
C. Converging occlusal wall  
D. Gingival cavosurface bevel
- 507. All of the following are true statements about pins in restorative dentistry except:**  
A. They are auxillary aids of retention in broken down teeth  
B. They are less expensive than cast restorations  
C. They are used in teeth with guarded prognosis  
D. They increase the compressive strength of the overlying restorative material

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| 492 C | 493 D | 494 A | 495 D | 496 C | 497 D | 498 C | 499 D | 500 C |
| 501 A | 502 D | 503 D | 504 A | 505 B | 506 B | 507 D |       |       |



- 508. The color matching for composites when done in a dry state, would make the tooth appear:**
- Darker than the adjacent teeth
  - Lighter than the adjacent teeth
  - Same as that of the adjacent teeth
  - Does not have any effect
- 509. Retraction cords facilitate all of the following except:**
- Better accessibility
  - Control gingival bleeding
  - Control crevicular fluid seepage
  - Provide anaesthetic effect
- 510. "Miracle Mix" refers to a:**
- Metal modified glass ionomer cement
  - Type of proportioning of dental amalgam alloy and mercury
  - superior mixture of filler and resin in composite restorative
  - mixture of Superoxol, Hydrochloric acid and Ether used for bleaching teeth
- 511. The FALSE statement regarding manipulation of Glass Ionomer cement is:**
- Mixing time for GIC should not exceed 45 to 60 secs
  - The mix should have a glossy surface
  - The shiny surface indicates the presence of poly acid that has not participated in the setting reaction
  - A clean glass slab and a flexible stainless steel spatula are best to mix the cement
- 512. An EBA cement refers to a:**
- Modified calcium hydroxide cement
  - Resin modified glass ionomer cement
  - Modified zinc oxide eugenol cement
  - Non-eugenol zinc oxide cement
- 513. Pin retained restorations:**
- Enhances retention of restoration
  - Enhances resistance of restoration
  - Enhances both retention and resistance of restoration
  - Enhances esthetics of restoration
- 514. Polishable composites refer to:**
- Unfilled resins
  - Conventional composites
  - Microfilled resins
  - All composite resins
- 515. Chemical preparation of a tooth for restoration with composite resin involve use of:**
- Citric acid
  - Hydrogen peroxide
  - Pumice slurry
  - Phosphoric acid
- 516. The cemented pins were introduced by:**
- Markley in 1958
  - Goldstein in 1996
  - Going in 1966
  - Mozer and Watson in 1979
- 517. The best method of increasing the working time of ZPC is by:**
- Cooling the liquid
  - Cooling the glass slab used for mixing cement
  - Adding a drop of cold water to cement
  - Increasing the liquid
- 518. The consistency of the cements can be quantified by measurement of the:**
- Viscosity
  - Flow
  - Angle formed by the cement on a plane surface
  - Film thickness
- 519. The agent used to provide barrier against passage of irritant into the dentinal tubules is:**
- Cavity varnish
  - Cavity liner
  - Cement sub-base
  - Dentin smear plugs
- 520. The metal in dental amalgam alloy in which mercury would dissolve maximum is:**
- Silver
  - Tin
  - Copper
  - Zinc
- 521. Itaconic acid in the GIC liquid:**
- Inhibit gelation caused by intermolecular hydrogen bonding
  - Serves as an accelerator
  - Increases the working time and reduces the setting time
  - Reacts with the powder to form the salt gel matrix



## 418 Textbook of Operative Dentistry

**522. "Rheology" is the study of:**

- A. Flow of matter
- B. Internal stress and strain in water
- C. Visco-elasticity of matter
- D. Dimensional changes of matter

**523. "Wet Corrosion" is an example of:**

- A. Atomization
- B. Halogenation
- C. Sulfurization
- D. Electrochemical corrosion

**524. The most unique feature of Nitinol alloy is its:**

- A. High hardness value
- B. Shape memory
- C. Ease of welding and soldering
- D. Ability to have high Cr/C ratio

**525. One of the major problems in firing dental porcelain is:**

- A. It gets oxidized easily
- B. The loss of strength
- C. The development of internal stress which on release distorts the fabrication
- D. The high degree of shrinkage that occurs

**526. Retention of gold inlay is maximized by:**

- A. Increasing the retention by luting agents
- B. Diverging wall of the preparation
- C. Increasing the axial length of the preparation
- D. Increasing the pressures during cementation

**527. The instrument formula numbers placed on the handle are in the following sequence:**

- A. Width of the blade, length of the blade, cutting edge angle
- B. Length of the blade, width of the blade, cutting edge angle
- C. Cutting edge angle, width of the blade, length of the blade
- D. Cutting edge angle, length of the blade, width of the blade

**528. Delayed expansion of amalgam starts:**

- A. Within 24 hrs      B. Within 3 to 5 days
- C. After 3 to 5 days      D. After 3 to 5 years

**529. The type of chisel that has a curved blade is the:**

- A. Straight chisel
- B. Binangle chisel
- C. Wedelstaedt chisels
- D. Hoe

**530. The property of least importance for a luting cement is:**

- A. Microleakage      B. Strength
- C. Water sorption      D. Water solubility

**531. Compomer is also known by the terminology:**

- A. Metal modified glass ionomer cement
- B. Resin modified glass ionomer cement
- C. Poly acid modified composite resin
- D. Flowable composite resin

**532. Value-a dimension of color as related to tooth describes:**

- A. The name of the basic color
- B. The degree of color saturation
- C. The lightness of darkness of a color
- D. None of the above

**533. The setting reaction of Glass ionomer cement is basically:**

- A. An acid base reaction
- B. Polymerization reaction
- C. Combination of acid base and polymerization reaction
- D. Chelation

**534. The cement base materials which have chemical adhesion to tooth structure are:**

- A. Zinc phosphate and zinc polycarboxylate
- B. Zinc phosphate and zinc oxide eugenol
- C. Zinc phosphate and glass ionomer
- D. Zinc polycarboxylate and glass ionomer

**535. Posterior composite restorations are successful in all of the situations except:**

- A. No occlusal contact
- B. Isthmus not wider than one third of intercuspal distance
- C. Moisture is not taken care of
- D. Gingival extension is sound enamel

**536. During cavity preparation with rotary instrumentation heat production is directly proportional to all of the following except:**

- A. Pressure
- B. Preoperative pain
- C. RPM
- D. Area of tooth in contact with bur

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|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 522 A | 523 D | 524 B | 525 D | 526 C | 527 A | 528 B | 529 C | 530 B |
| 531 C | 532 C | 533 A | 534 D | 535 C | 536 B |       |       |       |

- 537. The type of gold with highest strength to be used in stress bearing areas is:**
- Gold foil
  - Mat gold
  - Spherical gold
  - Electraloy
- 538. Pit and fissure sealants are generally not used in:**
- Molars
  - Teeth showing signs of opacity in pit or fissure
  - Patients receiving fluoride therapy
  - Cavitated lesion
- 539. The most reliable index for dentinal caries removal is:**
- Color difference
  - Depth of cavity
  - Tactile stimuli
  - Pain perception
- 540. The statement that is FALSE regarding proximal overhang of dental amalgam is:**
- They can be diagnosed visually and radiographically
  - They can be confirmed by a catch or tearing of dental floss
  - They confirm good gingival seat restoration
  - They can be prevented by the use of wedge and matrix
- 541. Copy milling is related to the:**
- Manufacturing of amalgam alloy
  - Fabrication of cast metal restoration
  - Fabrication of CAD-CAM restoration
  - Manufacturing of fillers in composite restorations
- 542. The wall that is not present in a class V cavity in an anterior tooth is:**
- Labial wall
  - Axial wall
  - Incisal wall
  - Gingival wall
- 543. Arkansas stone is used for:**
- Finishing direct gold restorations
  - Sharpening steel instruments
  - Finishing and polishing composite restorations
  - Polishing dental amalgam restorations
- 544. 'Command set' refers to dental material that hardens by:**
- Chemical reactions of base and catalyst
  - Chemical reaction by acid base reaction
  - Photo (light) activation
  - Autopolymerization
- 545. Composite restoration may NOT be fabricated:**
- Directly on prepared tooth
  - In dies and models
  - By heat polymerization
  - By casting using lost wax technique
- 546. Gingival cavosurface margin is beveled in a class II cavity for amalgam restoration to:**
- Get a lap joint on the cavosurface angle
  - Remove the unsupported enamel rods
  - Fet burnishable thickness of amalgam
  - Move the cavosurface away from the contact
- 547. The restorative material that is most anti-cariogenic is:**
- Composite resin
  - Dental amalgam
  - Calcium hydroxide
  - Glass ionomer cement
- 548. The rationale for placing a liner of GIC under a large and deep composite restoration in a molar tooth is:**
- Provide thermal insulation for the tooth
  - Seal the dentinal surface under the composite
  - Improve the strength of the restoration
  - Minimizing the chance for postoperative sensitivity
- 549. The material placed into deep cavities with suggestive reversible pulpitis is:**
- Zinc oxide eugenol
  - Glass ionomer
  - Calcium hydroxide
  - Zinc phosphate
- 550. Gingival wall in a proximal cavity preparation is located:**
- Within the interproximal contact
  - Occlusal to the interproximal contact
  - Apical to the interproximal contact
  - Apical to the interproximal crest of the gingiva